PETROLEUM REFINER

SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETRO-CHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

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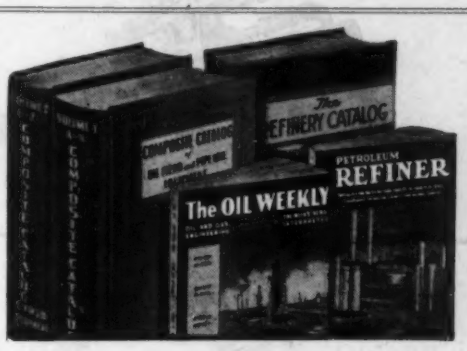

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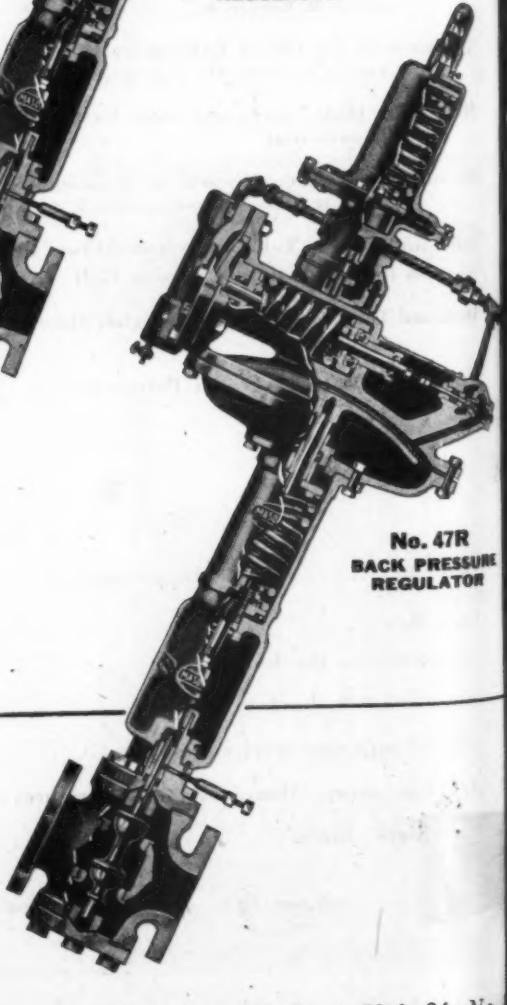

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THE LOOK BOX

A DECLINE of 41.5 percent in patents issued in the United States from 1933 to 1943 has drawn an analysis of causes in the July, 1945, Bulletin of Arthur D. Little, Inc. Since the filing of applications rather than patents granted reflects a better estimate of the trend in inventions, it is worth noting that the high mark for applications was 1930, when the total exceeded 90,000. For the 10 years previous, the average was around 85,000. There was a decline until 1933, then a rise to 1939, followed by a sharp drop to 1943. The rise to 49,000 applications in 1944 represents but little more than half the annual average for 10 years previous to 1930.

Inventions On Decline

Major cause for this trend was thus outlined in the Bulletin:

"It has also been shown that the curve of patent applications has followed closely the rise and fall of prospects for profit. The depression and heavy taxes may well have discouraged many individuals and smaller organizations in instances where speculation capital saw little chance of realizing profits even on successful inventions.

"The major factor in the decline of patent applications, however, is more fundamental in that it is not likely to be relieved by the cessation of the war. This factor is the increased severity of the government and the courts in their attitude toward patents, as evidenced by proposed legislation for major changes in the patent system and by decisions that present new obstacles to the patent owner and further restrictions on his field of activities. As a result the inventor and the manufacturer tend to place less reliance on patent protection and more on secrecy. The ultimate effect may be to curtail research. Both results are contrary to the avowed object of the patent system 'to promote the progress of science and useful arts,' which has fostered the industrial and scientific development of this country."

FOR those of a disposition to worry about a shortage of crude oil here is a piece of cheering news. Over in Florida there is a glorified farm project, part of which involves the growing and processing of sweet potatoes.

In Case of Shortage

Centrifuges remove the 70 percent of non-solid from the potatoes. This liquid is concentrated slightly and passed to digesters where it is allowed to ferment. This fermentation produces 1,000,000 cubic feet of methane each day for use as boiler fuel.

In case of shortage of oil and gas, the sweet potatoes can come to the rescue.

THE assumption that the petroleum industry will grasp the opportunity of entering the chemical field evidently misses the observation that petroleum is a big-volume industry. Its sales have been in billions of gallons and millions of barrels. Consequently it has become the victim of habit.

It's a Habit

It has been a profitable habit—this practice of selling many gallons and skimming off a fraction of a penny of profit from each gallon.

In fine chemicals, sales must of necessity be in

F A M O U S

Caustic Comments

An accused criminal stood before the court. He smirked at the judge, Lord Bacon, and pleaded, "Your Highness ought to let me free. You and I are really relatives. You see, my name's Hogg, and Hogg's kin to Bacon."

"Not until it's hung," was Lord Bacon's caustic reply.

ONE OF MANY DOW CHEMICALS USED BY AMERICAN INDUSTRY

Dow Caustic Soda

We have a *CAUSTIC* message also:

To satisfy industry's constant need for Caustic Soda and other heavy chemicals, manufacturers have come to depend on Dow. Quick shipment is assured by Dow's three plants strategically located in California, Texas and Michigan.

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DOW

CHEMICALS INDISPENSABLE TO INDUSTRY AND VICTORY

small quantities. It will require sufficient time for learning a new habit or overcoming an old one before the industry can look on chemical sales from the proper viewpoint.

The habit barrier no doubt is in part responsible for the partnerships which are coming into existence. The petroleum industry is providing the raw materials and some of the processing knowledge. The chemical industry will provide additional processing knowledge as well as sales approach.

These combinations look like good business.

The Old Pine Tree

NOW the southern pine tree has entered the chemical rubber sweepstakes with the promise of improving the wearing quality of GR-S rubber in casing treads. As explained by the B. F. Goodrich Company, this turn in chemical-rubber production "uses for emulsion a soap solution with a base of rosin acid, derived from the abundant southern pine," and "this special product has properties which reduce tread cracking and increase road wear."

A Goodrich plant at Louisville is producing this rubber at the rate of 15,000 tons per year and production has been added to the government-owned plant, operated by Goodrich at Port Neches, Texas.

This development is an instance in chemical progress. From crude oil and natural gas produced in the area, the oil and chemical industries are producing butadiene and styrene. Now the southern pine, a natural product of the same area, comes along to improve a chemical product.

Are They All There?

AMONG the recent new publications is the "Surplus Reporter," a dull but informative publication of the United States Department of Commerce, which is faced with the task of disposing of some of the surplus property accumulated for war purposes. That the buying services of the armed forces deals in high totals is evident from the listings.

For instance in a recent issue were such items: "3,231,374 screws, 2,876,208 washers, 129,222 bolts, 601,210 nuts." These totals are for certain sizes, for the publication lists other thousands, hundreds and odd figures for such merchandise.

No doubt the "Surplus Reporter" is enlightening to the man who needs the merchandise. But he who reads wonders who does all that counting.

Double Talk

IMAGINE the throwing of pop bottles that would ensue if some baseball pitcher asked for the privilege of calling his own pitches.

Still that is the double advantage of government when it gets into business. Its duty is to make the rules for doing business. Then when it engages in business, as it continues to do, it is a participant in a game for which it made the rules.

No pitcher with the count three and two, two out and the bases loaded, could throw anything but a strike, given the added privilege of umpiring.

Neither is government in business going to judge itself guilty under its own rules.

Chemists' Opportunity Along Coast of Gulf of Mexico

I AM profoundly impressed by this meeting of our South Texas Section of the American Institute of Chemical Engineers, impressed by the technical import of the six papers that were presented this afternoon and impressed by the 170 professional men present to listen to the speakers. In former years we could have such professional meetings only in the East. I little dreamed, when a boy in the San Antonio high school, that Texas ever would develop technically to the extent that this meeting shows it to have developed. I recall a remark made by a well meaning prominent state official who visited our high school class in chemistry, to the effect that the study of chemistry would be of no earthly good to us in Texas; that we should spend our time on matters of importance to the welfare of Texas. I wonder what he would say if he were present at this meeting.

Your presence at this meeting is a matter of great significance. It shows that you are interested in your profession; it shows that you are progressive; and last, but not least, it shows the people of Texas that the chemical industry has come to Texas in a big way.

The import upon each and every one of us which this meeting has is far reaching, not only through the wonderful vistas of new development opened to us by the speakers of this afternoon but also by the vivifying effect that common interests produce upon groups of people. It will stimulate us all into renewed professional activity as we return to our individual places.

You young men should stop to realize that this birth of a chemical era in Texas opens wonderful new possibilities before you. From here, at the shores of the Gulf of Mexico, there extend unexplored empires of technical opportunities in all direction, such as vast quantities of gaseous and liquid hydrocarbons, of sulphur, salt, limestone, metalliferous ores and non-metallic minerals to be developed in the countries adjacent to the Gulf of Mexico. Never before have opportunities such as these been placed before a body of men so well trained to develop them. It is up to you to show that you can use your mental heritage for the benefit of man. It is up to you, more than to any other group, to develop these regions. Nobody else has been trained to do this job as you have been trained. It is up to you to return to the world in kind what the world has invested in your education.

In closing I can not refrain from expressing my regret that I am not as young as you are, so that I can fully participate in the grand development which you will live to see here. But I am duly appreciative of the fact that I have lived to see the day when industry has arrived in Texas, the day when a technical and social meeting of chemical engineers, so large and splendid as this, can be held in Texas.

—Remarks of DR. E. P. SCHOCH, University of Texas, before the meeting of the American Institute of Chemical Engineers, Galveston, Texas, May 25, 1945.

HOW EVALIZING* CUTS VALVE WEAR, GALLING AND FREEZING

PROBLEM: In practically all steel valves there are some steel parts which must turn or slide freely in contact with other steel parts. But in many services, frequent operation, wide temperature and pressure variations and other factors result in wear and galling or binding between the parts. Operation of the valve becomes difficult.

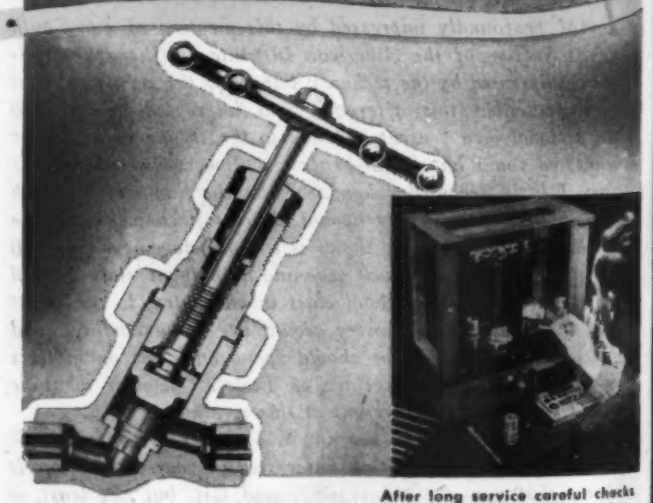
In special machines, built to Edward designs, Edward engineers have tested thousands of metal specimens for wear and galling or seizing characteristics. Electric furnaces make possible elevated temperature tests when desired. The general problem of abrasion has been under study in the Edward laboratories on such equipment for decades.

SOLUTION: One Edward answer to abrasion is EValizing,* an exclusively Edward process for coating steel valve parts with a bearing material which reduces friction between moving steel parts by about 25 per cent. It is applied electrolytically to such parts as the internal stem threads of all inside screw forged steel valve bonnets, junk rings, packing nuts, and, in the case of large high temperature, high pressure valves, the nuts used in body-bonnet bolting.

Section of the Edward EValizing department. Special fixtures permit plating of inside screw threads.

RESULT: Edward makes wide use of EValizing and the dividends are in much longer valve life and easier valve operation. For instance, long time tests show that a stainless steel stem can be rotated nearly 1000 per cent more in an EValized bonnet than an ordinary unprocessed steel bonnet. EValizing is a standard feature for many Edward valve parts, and is especially important on such valves as Fig. 2698 forged steel globe valve, right. Built in ¼ in. to 2 in. sizes, screwed or welding ends, and with a companion angle design, this low-cost, all-purpose valve is ideal for a multitude of services.

*Trade-Mark Registered



Widely used Edward Fig. 2698 forged steel stop valves showing areas regularly EValized.

After long service careful checks of EValized and non-EValized bonnets have been made. Loss in weight due to wear in Evalized bonnet approximates ½ that of normal untreated steel bonnet.

EDWARD *Steel* VALVES

THE EDWARD VALVE & MFG. CO., INC.
EAST CHICAGO, INDIANA

Look to Edward for the Best in New Steel Valve Developments

Safe Practices in Natural Gasoline Plants

DON ATTAWAY
Safety Engineer, Arkansas Fuel Oil Company

A good example of layout conforming to safety as set forth in this article is pictured in Arkansas Fuel Oil Company's plant located near Magnolia, Arkansas shown above.

STRANGE as it may seem, the birth of natural gasoline was an accidental event. It resulted from a series of circumstances and conditions met in the operation of some oil wells near Sisterville, West Virginia in 1903. These wells were owned by Sutton Brothers and Edwards, who had laid four or five miles of pipe to transport gas to a boiler. No sooner had the line been installed than trouble began and upon investigation, considerable quantities of gasoline were found in the sags and low spots in the line. These men, observing that the cooling of gas caused gasoline to condense, installed a system of coils in an old boiler and tank filled with water, and natural gasoline manufacture began.

Later, experimenters discovered the process whereby charcoal was used to absorb the gasoline from the gas and the liquid recovered by steaming the charcoal and cooling the vapors. In 1913, William Mayburg of New York began the compression and cooling of gas for natural-gasoline extraction and within the same year, George Saybolt developed the process which consists of bubbling gas through a petroleum distillate which absorbs the gasoline, to then be recovered by distillation.

The business has grown to more than 100 companies today operating more than 700 natural-gaso-

line plants and employing more than 10,000 workers.

The hazards of this business are many, as natural gasoline is one of the most volatile and inflammable liquids utilized by man. Air containing as little as 15 percent gasoline vapors by volume is explosive. Mixtures containing as much as 6 percent vapor with as little as 12 percent oxygen will burn. Besides its burning qualities, air containing 0.2 percent gasoline vapors is likely to asphyxiate workmen.

Most men engaged in the manufacture of natural gasoline feel safer in the plant yard than they do on the streets and highways, but once in a while a disaster occurs in one of the plants and the property loss and personal injury is severe.

The gasoline-plant worker is beset by certain physical conditions that entail natural hazards. In his work, he must contact pressure, temperature, and inflammability. Ignition sources in a gasoline plant are many. He is exposed also to falls, moving parts, and the human unsafe acts.

In spite of its inherent dangers, the natural-gasoline industry as a whole shows an average frequency of 11.46 lost-time accidents per million man-hours worked, which is well in line with the petroleum industry experience of 11.72 lost-time accidents per million man-hours worked. However, recent United States Bureau of Mines surveys and accident statistics show that the small natural gasoline companies suffer rather heavily from accidents and record a frequency of 26.57 accidents with 9.72 of them being severe or resulting in death.

This article, therefore, is intended to provide information based on actual experience and accumulated from various safety regulations. These practices are not to be confused with federal state, or insurance laws and regulations.

Plant Layout

Safety must be incorporated into a gasoline plant with the orginial designing. Four primary factors should be kept foremost in mind when planning such a plant: safety, economy, efficiency, future expansion.

The first step in designing a plant is to make a study of the site with special attention to the terrain, prevailing winds, and character of surrounding property with the view in mind of proper unit location.

The interest of safety as well as utility is best served if the pumps, compressors, and boilers are placed on one down flank of an elevated ridge, and absorbers, stills and storage tanks on the other. The cooling tower should be on the crest of the hill or highest portion of the plant.

The boilers should be set at least 150 feet from danger areas and not less than 25 feet from the property line. They should be on the up-wind or opposite side of the plant from the storage tanks. Fire stills should receive the same consideration as boilers.

The compression plant should be at least 75 feet from the stills and absorbers, and the building should be set at right angles to the prevailing winds to benefit ventilation.

Storage tanks should not be less than 50 feet from the property line and at least 310 feet from the boilers and 235 feet from the engine room. If horizontal tanks are used, they should be set so that either head of the tank does not point toward the plant or a dwelling, as such tanks usually hurl themselves in a longitudinal direction in an explosion.

The loading rack should be no closer than 100 feet to any structure, building, or thoroughfare.

The office, warehouse and laboratory should be reasonably close to the plant but well outside the danger zone and directly opposite the storage tanks. There should be no walk or roadway required through the plant to reach them.

Isolated plants, some distance from towns, usually provide cottages for their workers. These dwellings should be 200 yards from any fire or explosion hazard.

Steam, oil and gasoline lines are preferably installed overhead for safety as well as economic reasons.

Water and drain lines usually are located underground although corrosion and complications involving dead and forgotten connections may arise.

Piping to pumps should be free of short turns and dips, and check valves should be installed on all lines where back-flow may create unsafe conditions.

Control panels and instruments are better located on individual units in natural-gasoline plants.

Absorbers, Stills and Columns

The design of stills, absorbers and other unfired pressure vessels must be based on API and ASME codes.

Anchored or self-supported columns are preferred as they eliminate the use of guy wires which may create hazards.

All pressure vessels must have a safety relief valve of adequate capacity for excess vapors or liquids. The discharge should be vented high in the air and the vent line should have a drain hole at its lowest point.

Each vessel or column should have an indicating pressure gauge with a range two and one half times the operating pressure. Gauge glass connections should be on all tanks or columns handling liquid.

Automatic control of absorption oil circulation is good practice. Pilot-operated regulators and liquid-level controls should be so installed that failure of instrument supply will not suddenly halt circulation. Over-circulation is not necessarily unsafe, whereas halted circulation creates a hazardous condition.

The distillation unit is the heart of a natural-gasoline plant. The efficiency of the plant, as well as the quality and quantity of the finished product, depends largely upon the attention given this system.

Good operating practice is to see that the load is evenly distributed between units and that the oil delivery is free of water or emulsion. The vent tank controls should be adjusted to give uniform oil flow and deliver all vapors coming off to the vapor system.

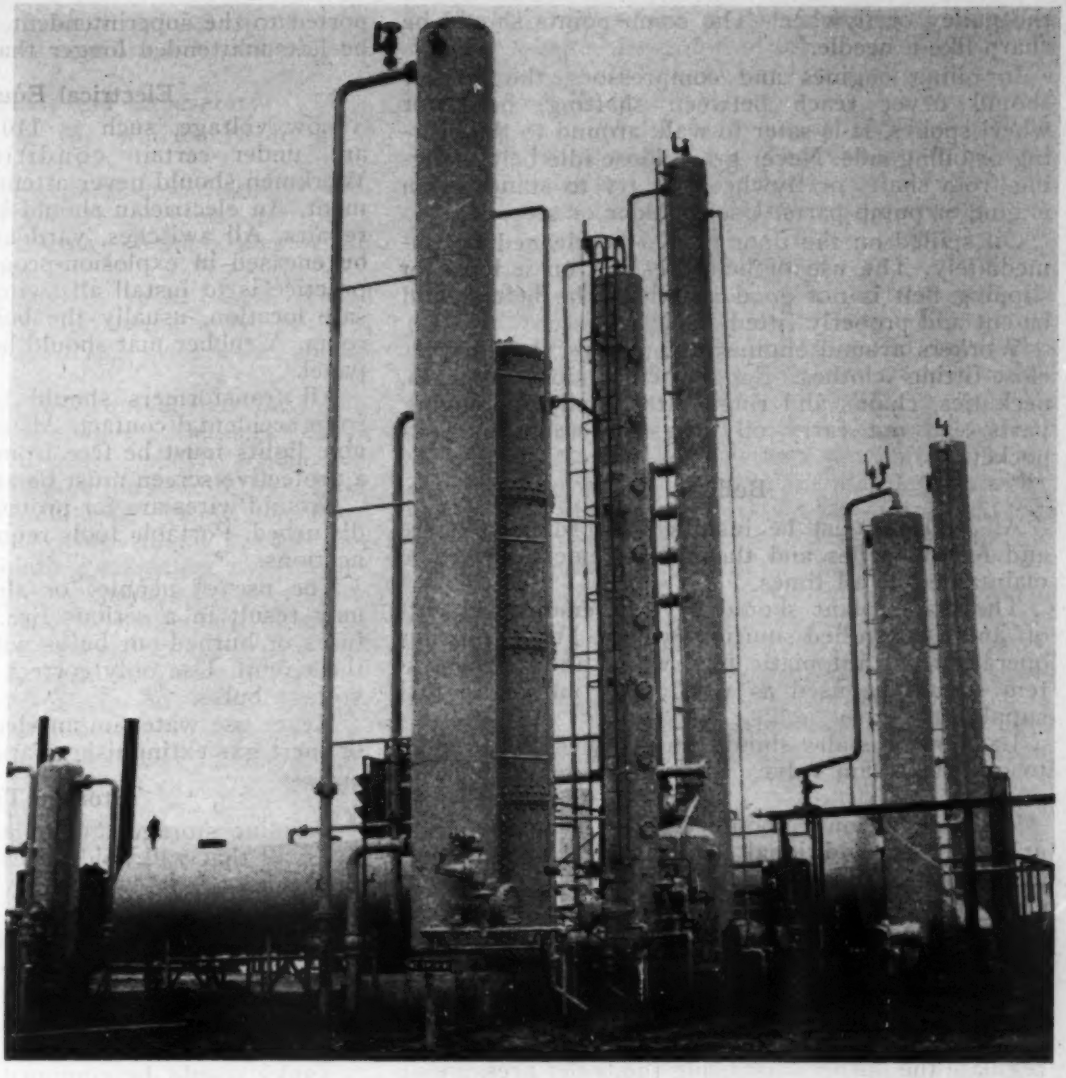
Heat exchangers and preheaters should be kept clean and free of leaks.

The feed to the still stripping section should be uniform and the proper amount of dry steam must be admitted. Traps or drains must allow no water accumulation in the still.

The still pressure and temperature must remain constant and the reflux delivery uniform.

All traps and separators must be checked often to see that no oil or gasoline is being discharged into the drain or water system.

Safe practice demands a suitable scrubber of ample size, equipped with liquid-level control alarm,



Absorber arrangement with distillation unit in background. Note relief valve locations and ladder guard.

on all intake lines to compressors. The alarm should be arranged so that an excess increase in liquid level will shut down compressors by grounding out ignition.

Safety alarms are desirable on intermediate scrubbers, and ample relief valve protection is necesssary on all scrubbers in case of a sudden shut-down. Each scrubber should have ample drain connections for frequent draining.

All compressors should have automatic shut-downs in case of abnormal jacket water temperature, low lubricating oil, or over-speed.

Vibration often creates leaks and all piping to compressors should be checked frequently.

Always unload compressors before starting by releasing gas to air or opening by-pass so that equal pressure is on intake and discharge valves.

A check must always be made to see that the discharge valve is not closed before starting the engine.

The starting air should have the engine turning over freely before fuel is admitted. If fuel is opened too soon or ignition is turned on while the muffler and exhaust is full of gas, an explosion may result.

When starting belt-driven units, stand to one side of the belt to prevent being struck if the belt breaks. Never stand directly in front of an engine or flywheel when starting.

In stopping engines, never pull or disconnect ignition wires. Do not check ignition by holding the wire an inch or so away from the plug. Stray or leaping sparks may ignite gas that is present.

The discharge valve should never be closed until the flywheel comes to a complete stop. The mixing valve should be closed when the engine stops to prevent fuel leakage.

No compressor should be left in operation longer than 30 minutes between inspection rounds.

Many accidents occur in compressed-air starting systems. Air compressors should be two-staged for best practice and a temperature of 350° F. should not be exceeded in discharge air. As small amount of oil as practical should be used for lubrication.

The discharged air should be scrubbed and cooled before entering a receiver, and all air lines to gas engines should have bleeders and drains to remove any remaining fluid that might not fall out in the receiver.

The air tank or receiver should not be indoors and should be equipped with an adequate relief valve and pressure gauge. A drain should be installed in its lowest point and blown regularly.

A check valve should be directly in the discharge line of each air compressor cylinder.

Air compressor intake lines should be outside of buildings and properly screened and shielded.

Proper guards and rails should be around all moving parts of engines and compressors as well as belt runways.

Belted units in plants generate static electricity. The safe practice is to install a wire comb grounded and placed in contact with the belt where it leaves

the pulley or flywheel. The comb points should be sharp like a needle.

In oiling engines and compressors, the worker should never reach between shafting, belts, or wheel spokes. It is safer to walk around to the bearing or oiling side. Never grasp loose idle belts hanging from shafts or flywheels or try to stand on an engine or pump parts. Use a ladder or step.

Oil spilled on the floor should be cleaned up immediately. The use of belt dressing on a loose or slipping belt is not good practice. The belt should be cut and properly fitted.

Workers around engines and pumps should wear close-fitting clothes. Ragged cuffs, loose sleeves, neck ties, chains and rings catch easily in moving parts. Do not carry oily rags or waste in your pockets.

Boilers

All boilers must be installed according to state and federal codes and these requirements must be maintained at all times.

The boiler plant should have a remote fuel cut-off and a controlled snuffing system. For safe boiler operation, an automatic feed water and alarm system should be used as well as an automatic fuel supply.

Ladders or stairs should be installed for firemen to operate steam valves without danger of burn or scald.

The boiler house should have at least two safe exits and an additional door for each two boilers installed over three.

To fire up a boiler, the water level should first be checked in gauge glass and try-cocks. All fuel and pilot valves should be checked before inserting the torch into the firebox. Be sure to stand to one side of firebox opening when opening the fuel valve. Do not look into peep-hole. After the fire has ignited, regulate the burners and bring the boiler pressure up slowly to main line pressure before opening the main steam outlet valve to the header.

A boiler should be taken out of service slowly to prevent sudden or undue stress or strain upon its structure.

If, at any time, water is below gauge glass or try-cock level, shut off fuel immediately. Do not open safety valve or try to close steam valve. Above all, do not admit water to the boiler.

Never try to repair a leaky tube, header, or shell with pressure on the boiler.

Never enter a boiler or firebox until it has been cooled, ventilated, and all gates blocked and marked. Double stops on steam headers and blow-offs must be closed and bleeders open.

All boiler gauge glasses should be screened or guarded. To replace a broken gauge glass, close both valves and remove guard. Remove all broken pieces. Make sure new glass is proper length. Insert the glass and set up nuts but not too tight. Replace guard and open top valve slightly to warm glass. Close the drain cock, open bottom valve slightly and check for leaks. When water level is steady, open bottom valve wide and then the top valve.

Safety valves, try-cocks and gauge-glass columns should be tested at least once each tour or oftener if conditions require.

Boilers should be blown down once each tour or oftener when water conditions are bad. All boilers must be washed and cleaned at regular intervals.

All unusual operating conditions should be reported to the superintendent. A boiler should never be left unattended longer than 20 minutes.

Electrical Equipment

Low voltage, such as 110 volt lighting circuits are, under certain conditions, very hazardous. Workmen should never attempt to repair line equipment. An electrician should be called to make such repairs. All switches, yard and plant lights should be encased in explosion-proof containers. The safe practice is to install all switches on one panel in a safe location, usually the boiler house or auxiliary room. A rubber mat should be used in front of such panel.

All transformers should be caged and guarded from accidental contact. All extension cords or portable lights must be free from breaks or cracks, and a protective screen must be around the globe.

Ground wires are for protection and should not be disturbed. Portable tools require proper ground connections.

The use of pennies or slugs behind fuse plugs may result in a serious fire hazard. Never replace fuses or burned-out bulbs without first shutting off the circuit. Use only correct fuse links and proper-voltage bulbs.

Never use water on an electric fire. Dry chemical or inert gas extinguishers are better.

Storage Tanks

Gasoline storage tanks should be protected by a fire-wall that will hold at least the total contents of the tanks.

All storage tanks require adequate relief valves and a safe practice is to connect all vapor-relief lines from the tanks into a common line. This makes all valves available in an emergency and is a safety factor in preventing ruptured tanks resulting from overfilling.

Tanks should be equipped with a connection for installing a check valve against tank pressure so that a vacuum will not be created and pull in the tank.

Stairways with adequate hand rails and walkways are preferred for storage-tank-battery operations.

Proper warning signs should be displayed on all sides of storage-tank batteries.

All gauges, drains, and bleeders should be kept in good condition and protected from accidental breakage or freezing.

Loading Racks

Loading gasoline is a task that requires close attention and rigid safety-rule observance. The loader should be an experienced or trained man familiar with the rules and regulations of the Interstate Commerce Commission and the Bureau of Explosives. He should make frequent and thorough inspections to see that his loading rack and equipment are in safe condition at all times.

Loading racks should be made of metal with at least two stairways for emergency exit. Each rack should have suitable bonding devices.

Fire is the most serious hazard in loading operations due to the release of inflammable vapors and the many ways in which they may become ignited. Ample drainage should be provided for spilled gasoline. "No smoking" and other warning signs should be prominently displayed at all times. Loaders must not carry matches during loading operations.

No loading should be done during electrical storms.

Falls produce most loading-rack accidents, and

loaders should not jump from rack to car or from car to car. Walkways and platforms should be used.

Warehouse, Office and Laboratory

Good housekeeping is the watchword in good plant operations.

Warehouses should be kept clean and orderly with proper racks, bins and lockers for tools, parts, and fittings. Yards and platforms should be kept clean of refuse and junk piles.

Material should be piled or racked with regard to safety. Aisles, floors, and steps must be kept clean and in good repair. Each warehouse should have a hand truck.

Offices are usually the first contact with the public and must be kept spic and span. Accidents can result from projecting desk drawers, pencil sharpeners, loose thumb tacks and broken glass desk tops. Keep waste paper from accumulating. Proper electrical equipment, guards, and wiring should be used for fans, desk lamps, calculating machines and such.

The laboratory requires special fire-prevention practices. All sample bottles or containers should be kept capped or corked when not in use to prevent spillage or breakage. Laboratories should be well ventilated as waste vapors tend to collect in such places. Sink drains should be made with seals so that discarded oil samples may not be ignited or back-flash.

A good practice is to pipe such drains to a settling tank or skimmer basin for oil recovery.

Smoking should only be permitted under safe conditions. Provide liquid cuspidors or ash trays and do not discard cigarette butts or ashes on the floor.

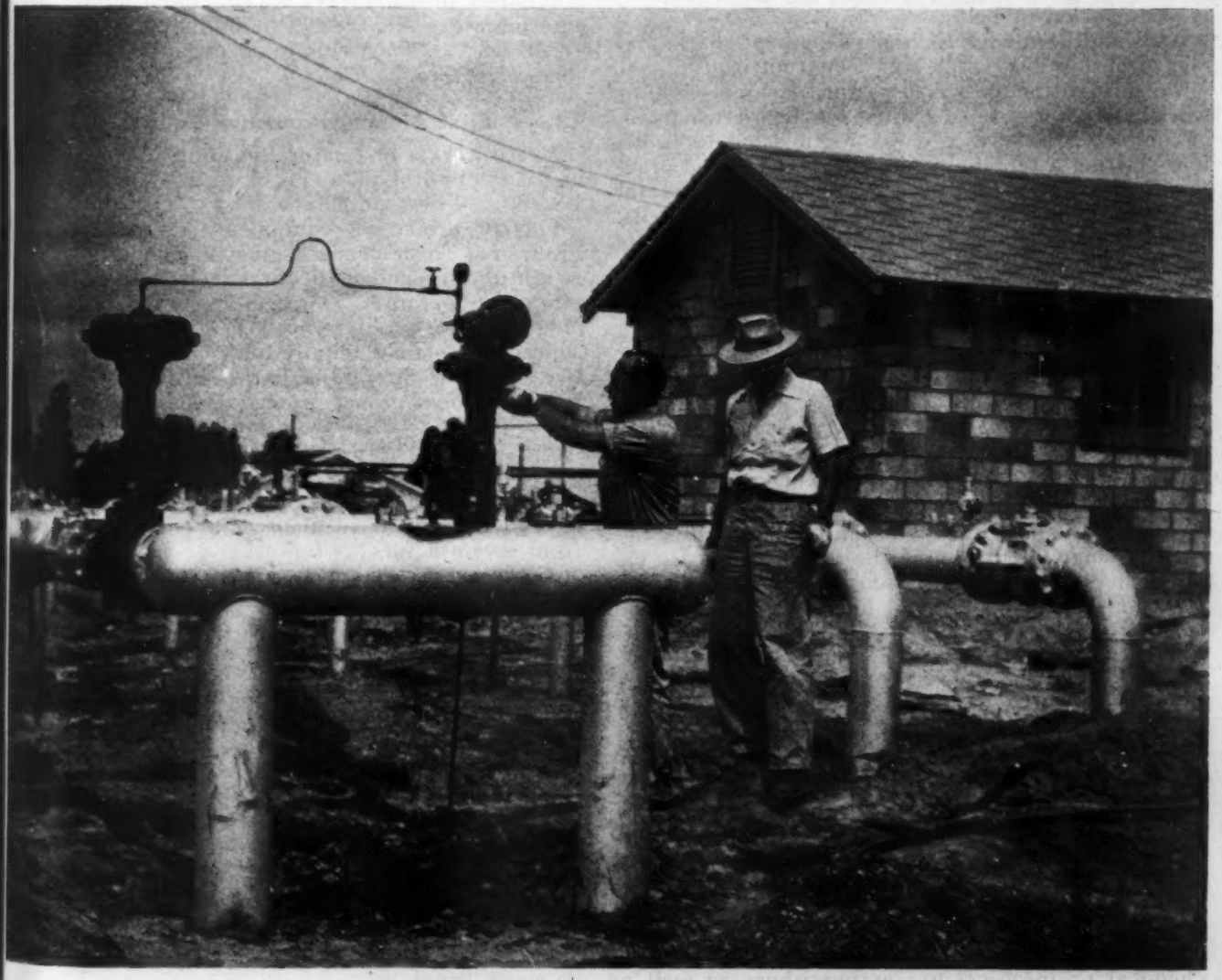
Toilets, washrooms and fountains must be kept clean and sanitary. For the health and safety of all, workers should observe the rules of decency.

Field Lines

The safe and efficient operation of field lines depends upon the degree to which liquid is kept out of the lines. Plant inlet scrubbers and separators can only handle liquid arriving at the plant, while every low place in the field line offers a place for liquid to accumulate and reduce line capacity. Drips should be placed a short distance downstream of the lowest spot in the line, usually one half pipe diameter. On vacuum lines the drip should be so arranged that a connection may be made on the residue line to secure pressure for blowing out the liquid.

Often such drip fluid is collected in drums or tank trucks for processing, but sometimes, a blow-off line to a burning pit is installed and a serious hazard created for the worker who blows and burns the drip fluid.

These burning pits should be in an open area with an adequate fire-wall and should be fired from the upwind side. Do not attempt to burn a pit of



Controls and regulators require occasional lubrication and adjustment

fluid on a still, danp, windless day or in valleys or bottoms where vapors may collect and remain for some time. Beware of leaking drip connections where vapors may escape or collect in weeds, grass or low places.

All field lines should be walked at regular intervals and inspected for leaks.

Hand Tools

Hand tools account for one out of every ten accidents. These mishaps result from tools being used incorrectly or tools in unsafe working condition.

Every plant should have an adequate tool board or cabinet for each unit. These tools should be inspected at frequent intervals and such defects as sprung jaws, broken cages, handles, faces, or mushroomed heads corrected at once.

All files require handles, and a file should never be used as a chisel or pry bar.

Always put a wrench on so as not to spread the jaws and use the right size to fit the work. Do not use a wrench as a hammer.

The screw-driver should not be used as a chisel or lever. Do not hold the material being worked on in your hand when using the screw-driver.

Use of extensions on wrench handles is bad practice. Pipe wrench jaws, as well as chains and tong keys, must be kept in good condition or wrenches will slip.

It is dangerous to carry sharp or pointed tools in your pocket or belt.

Axes and keen-edge tools must be kept sharp, and racked on low boards or bins when not in use.

Do not scatter tools on floor or machine while at work and always replace them on board when job is complete. Be sure to check for missing tools before starting a repaired compressor. It is good practice to turn the engine over by hand or jack several times to make sure there are no loose parts or tools.

Only non-sparking tools must be used in areas where explosive vapors are present.

Always wear goggles when grinding, chipping or exposed to splash, dust or vapors.

Fire Protection

Adequate fire-fighting equipment of the correct type must be maintained at all times. Fire extinguishers should be housed or otherwise protected from wind, weather and sun. Fire-cart houses, cabinets and racks should be painted red for easy identification and location. All equipment should be checked frequently for condition and tagged with date of last refill.

Every man should know the operation of fire extinguishers and demonstrations given new men.

Water is the best general fire extinguisher but it is of little value on an oil or gasoline fire as it causes it to spread and is hazardous on electrical fires unless used in special fog-nozzle equipment.

Dry chemical or inert-gas fire extinguishers of the hand type should be used on indoor fires. These extinguishers are best located near an entrance or exit door of such places as offices, laboratories, warehouses, compressor and pump rooms.

Cart foam extinguishers are valuable near pump batteries, stock tanks and oil storage.

Dry chemical or inert-gas extinguishers are suitable near absorber batteries where gas fires are more likely to occur. These should be of the cart type.

The loading rack should have at least two dry-chemical or inert-gas fire extinguishers as well as water barrels and sacks. One extinguisher should be on the rack and another on the ground level. Racks having a capacity of more than five cars require additional extinguishers and extra large racks should have fire-cart installations.

Non-conductive hand extinguishers should be bracketed or hung near electrical motors and transformer cages. In case of fire, the current should be shut off as quickly as possible.

All plant automobiles should carry hand-size fire extinguishers bracketed near the door or dash. All trucks should carry dry-chemical or inert-gas extinguishers in vertical holders on the outside of the cab, preferably on the right hand side and between the cab and the bed. Tank trucks usually mount the extinguishers on the right side running board.

Ample refills and spare cylinders should be carried in the plant warehouse at all times and fire extinguishers immediately refilled after use.

Welding

Installations or repairs in a plant that require welding produce extra hazards and this operation should never be undertaken until all safety precautions have been made. (See "Safe Practice in Welding and Cutting" International Acetylene Association, New York.)

Before any plant vessel is welded, it must be steamed, ventilated and certified as "gas-free." No closed vessel should ever be cut into or welded.

Welders should always unclasp torch lighter when entering a gaseous area. A bump may cause a spark.

All workers in welding operations should wear shaded goggles.

First Aid and Protective Equipment

Every worker in a natural-gasoline plant should be instructed in first-aid and each plant should maintain a well-filled first-aid cabinet.

Certain protective equipment, such as goggles, respirators, fresh-air masks, non-sparking tools, dead-weight testers, and gas testing devices, is essential to safe plant operation. This equipment should be available at the point it is most likely to be used, and supervisors should require and encourage the practice of never attempting work involving exposure hazard without proper protective equipment.

General

From the safety engineers standpoint, there is no difference in safety and operations. Good operation, as well as basic accident prevention, can be secured from seven factors, as follows:

1. Proper design and layout of equipment.
2. Selection of men physically and mentally fit for the job.
3. Provide proper mechanical guarding and maintenance of equipment.
4. Develop safe practices for the different jobs.
5. Instruct workers in correct methods.
6. Supervise closely to insure safe working procedure.
7. Provide and use suitable protective equipment.

Every plant should have one man devote a considerable part of his time to safety.

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Engineering Problems Involved in Gas Turbine Development

W. A. WILSON

THE term gas turbine is so broad that it may not be out of place to qualify it for purposes of our discussions today. The primary distinction to be made is that existing between the gas turbine, as an isolated machine, and the aggregation of units which comprises a gas turbine power plant. This differentiation becomes necessary when we realize that while a gas-turbine power plant is still a novelty, gas turbines are an engineering commonplace.

It is no trick to build a turbine for operation on air or other gases instead of steam. Elliott Company for more than ten years has furnished mechanical drive turbines for operation on natural gas instead of steam.

In common with most gas-turbine installations in the petroleum industry these units operate at conditions of temperature and pressure which are less severe than those encountered in modern steam plants. In such applications it is only necessary to follow good established engineering practice to secure a turbine which will convert energy available, in the pressurized and heated gases associated with the particular process, to appreciable amounts of mechanical work.

In 1940 Eliott Company designed and built a turboblower for operation in connection with a Kellogg hydroformer (this is analogous to other catalytic process as making use of the gas-turbine principle). This turbine was designed for operation on gas at 850° F., a conventional temperature for this type of application.

The exhaust-gas-driven supercharger as applied to aircraft and diesel engines is one step closer to the gas-turbine power plant. It employs the high-temperature exhaust gas from an internal-combustion engine to supply the work necessary for supercharging, thereby considerably increasing the economy of the prime mover.

However, the interrelationship of engine, compressor and turbine characteristics is very involved; designs must be nicely balanced with respect to exhaust temperatures and pressures and the degree of supercharging. Turbine and blower efficiencies are important, and turbine operating temperatures are in the region where metals glow visibly in the dark.

Elliott has been producing turbosupercharges for four-cycle diesel engines since 1941. Practically every manufacturer of four-cycle diesels is using or is preparing to use our turbochargers. Some 1300 units have been put into heavy-duty service in marine, rail, and stationary applications. As opposed to aircraft units having limited life, they are designed to operate continuously for 100,000 hours. They represent such an important preliminary phase of gas-turbine development that I would like to make some comments on their construction.

THIS paper was one of several which made up a forum, sponsored by the Elliott Company at Jeannette, Pennsylvania, where the first gas-turbine power plant for ship propulsion was given public demonstration.

The influence of the gas turbine on the refining industry is such that its development deserves close study. As a turbine it offers opportunity for harnessing gas in process for power in plant operation. As a super-charger it improves the efficiency of the internal combustion engine by so much that it will have effect on consumption of fuels. When carried to the fullness of a power plant, as described in this paper, it offers additional outlet for products of refining.

The unit was demonstrated as a consumer of fuel of the diesel grade but experts predict that it can be operated on lower-grade fuel oils and eventually on Bunker C oil. Its thermal efficiency of 29 percent is accepted as a step toward an efficiency of 32-34, comparable with diesel performance.

In one of the other papers on the July 23, 24, 25 program, C. Richard Soderberg compared the gas turbine with other prime movers and gave this estimate of the new development.

"It is evident from this very sketchy comparison with the other prime movers that the gas turbine is certain to play an important role in the future. We are just starting a new chapter in the history of prime movers; we know that the chapter will be written, but its exact content is still hidden from us. Like all other inventions, the gas turbine will gradually and slowly find its proper place, and it is more than likely that this place will be one which neither the steam plant nor the diesel engine occupies at the present time. The steam plant and the diesel engine will probably continue to be important in their respective fields, but the presence of a new contender is also likely to precipitate important developments in these prime movers. It is certain that in this process the entire prime mover picture will undergo far reaching modifications."

A cutaway section of the turbocharger is shown in Figure 1. The general arrangement is a single-stage turbine wheel mounted on the same shaft with a cast aluminum blower impeller. The assemby includes a complete lubrication system and an intake silencer. Exhaust gases from the diesel engine cylinders are directed into the turbine wheel. These gases, at temperatures up to 1020° F. are separated by a matter of a very few inches from the blower assembly which operates at perhaps 160° F. The blower delivers compressed, cool air directly to the intake manifold of the engine. The proximity of the high-temperature turbine wheel and casing to the parts operating at more nearly ambient temperature poses many difficult problems of mechanical construction and cooling. The trouble-free service which this unit provides attests to the success with which these problems have been met. Two principal factors contributing to successful cooling are the use of a water wall partition between the turbine and blower casing and a supply of cooling oil to the shaft and

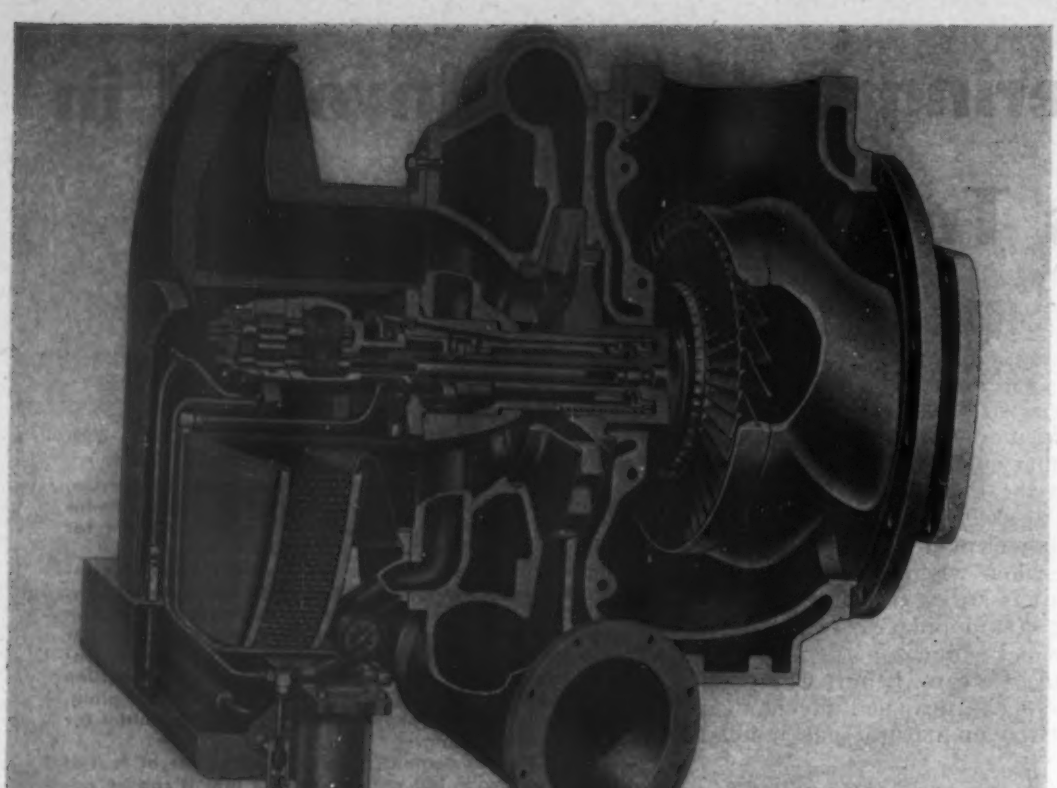

FIGURE 1
Cutaway section of turbocharger.

bearings. Note that the inboard bearing is actually located virtually within the turbine housing. Nevertheless, it is possible to operate at oil temperatures which are no higher than conventional.

All of this serves to give some insight into the background Elliott possesses for gas-turbine development and is by way of distinguishing between the "gas turbine" as an auxiliary piece of apparatus useful for utilizing otherwise wasted energy, and the "gas-turbine plant." The latter is a prime mover, and as such is strictly accountable for the fuel it burns.

Our turbocharger experience bridged one of the two major gaps in engineering technology which have for years frustrated atempts to produce gas-turbine power plants. This experience furnished the necessary incentive for metallurgical research, and resulted in the development of materials suitable for operation at red heats. It was only our thousands of hours of supercharger operation that gave us the necessary confidence to proceed with more ambitious turbines.

One look behind the insulation of a gas turbine in operation reveals metal which would ordinarily be considered ripe for the blacksmith's hammer. The metallurgist's problem is immediately apparent, as well as the necessity for a background of experience such as ours with the turbocharger.

The other major requirement of the efficient production of power by gas turbines was a means of compressing large volumes of air economically. Probably the most obvious feature of a gas-turbine plant is the compressor or compressors and the relatively great power required for compression. This power has such an apparent parasitic nature that it is well to remind the observer that comparable amounts of non-useful energy are dissipated by all thermodynamic machines.

In the internal-combustion engine the power cylinder is also a compressor cylinder, and energy is removed from the crankshaft on each compression stroke. In addition, the engine exhaust carries away large amounts of low-grade heat.

In the steam-power plant the condenser cooling water must dissipate the heat of vaporization originally supplied in the boiler. It is a sad thermodynamic fact that we are unable to make more than a fraction of the heat energy of our fuels available for conversion to useful work in any known heat engine.

In the gas-turbine plant the unavailable heat appears as compressor work. As in the case of the otto and diesel engines, this compression work is taken directly from the power shaft. But while the reciprocating machines are inherently efficient compressors, rotary machines to handle the volumes of air required to operate turbines big enough to afford reasonable efficiencies and power outputs have proven a stumbling block for many years. It is comparatively recently that one of Sir James Parson's inventions, the axial flow compressor, has been developed to the point where it will compress air with the necessary efficiency for gas-turbine applications. At approximately the same time, centrifugal compressors advanced to a similar position.

The axial flow machine is in essence a turbine running backward, and the centrifugal type is similar to a Francis water wheel reversed. Both are good demonstrations of how much more difficult it is to make water run up-hill then down. It is, in fact, possible to do so only for a rather narrow range of conditions, or combination of conditions.

Consequently, when compressors of these types are used on gas-turbine plants they seriously restrict the plant's operation with respect to part loads and starting conditions. As long ago as 1935 the Ljunstrom Company of Sweden built a gas-turbine plant

employing centrifugal compression. The instabilities encountered in the operation of this plant were so severe that they were impelled to undertake the development of an entirely new means of compression. This program culminated in the design of the Lysholm compressor.

This outsized meat chopper illustrated in Figure 2 is a remarkable combination of the advantages of a reciprocating compressor and those of a strictly rotary machine. Despite its outlandish appearance, this machine is essentially very simple. It has only two moving parts of exceptionally rugged construction. The two co-operating rotors, which are timed by the ground gears directly mounted on their shafts, are journaled in precision automotive-type bearings specially selected to give indefinite life and reliability of operation. All parts are enclosed in an accurately machined casing scientifically jacketed to insure symmetrical temperature distribution, producing correct alignment of parts even under the extreme conditions of operation and temperature.

While running at the high speed characteristic of turbomachinery, it inhales successive bites of air which are enclosed, cut off and compressed by squeezing, and finally pushed out into the exhaust system. At both the intake and exhaust the successive bites overlap so that a continuous flow is obtained.

This is a genuine positive displacement machine which for each turn of the shaft takes in and compresses a fixed volume of air independent of the back pressure imposed. That is to say, over a very broad range the operating pressure can be independent of air qauntity. This has the practical effect of allowing selection of a flow-pressure relationship exactly suited to the associated turbines. Consequently, a gas turbine plant employing these compressors has a flexibility previously believed to be unrealizeable. An important concomitant is the amazingly efficient part-load operation, which is of special significance in marine-propulsion machinery.

In 1940 Elliott Company was given the opportunity to test a small Lysholm compressor, and subsequently to build several small-capacity units. Having become convinced of the potentialities of this method of air compression for gas-turbine application, and being assured by our turbocharger experience of adequate high-temperature materials, we were prepared to embark on a full-scale development. Although compressors and materials were two of the most important prerequisites for our gas-turbine development, they were far from a guarantee of success.

The handling of large quantities of red hot air in high-speed machines presents many new problems, not all of which are easily foreseen. Success of the entire project is predicated on thermodynamic analysis of the basic cycle, and on accurate prediction of the characteristics of machines designed to implement it.

Each of the plant's major components is a vital link in the chain that comprises the overall cycle. Turbines, compressors, heat exchangers and combustion chambers—eight major parts—are each one indispensable and consequently capable of blocking success of the entire assembly. As with all new engineering developments of major proportions, it is easily appreciated that each problem encountered, whether it was an item of thermodynamics, mechanism, combustion, thermal expansion, insulation or high-temperature strength, became a matter of considerable importance. Some of the solutions have been novel, and practically all have achieved some degree of success. Collectively, they make up our initial answer to the long-standing question of what it takes to build a practical gas-turbine plant.

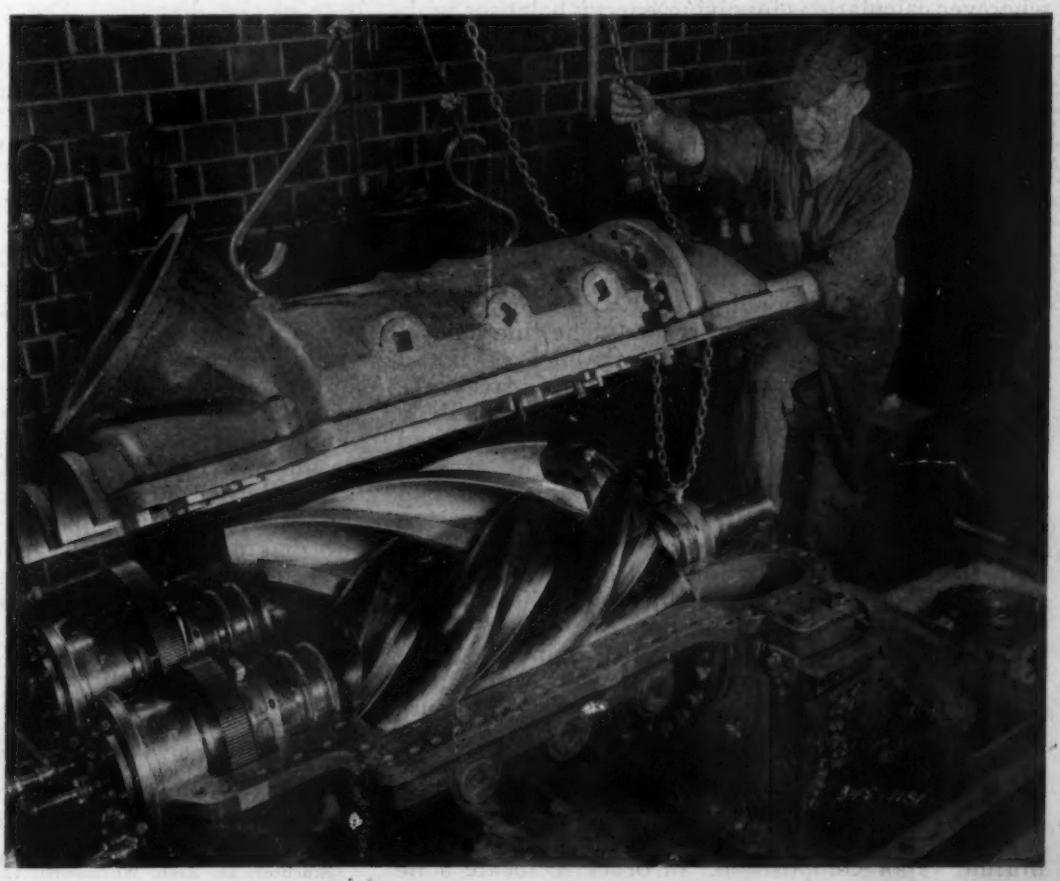

FIGURE 2
Lysholm Compressor

The Enthalpy-Composition Diagram for the System Ethanol-Water

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SYNOPSIS

The enthalpy-composition data for the system ethanol-water at one atmosphere pressure is presented in two charts (opposite and succeeding pages) showing liquid isotherms, vapor isotherms, the saturated liquid line, the saturated vapor line and equilibrium tie lines.

ENTHALPY-composition diagrams are useful wherever calculations involving energy balances with binary systems are required. The accompanying charts were prepared from data taken from the literature.[2, 3, 6, 7]

Figure 1 shows the enthalpy-composition diagram for the system ethanol-water at 1 atmosphere pressure and is intended to show primarily the liquid isotherms. The reference states of zero relative enthalpy are liquid water at 32 °F. and liquid ethanol at 32 °F. The line labeled "saturated vapor" shows the enthalpies of vapor mixtures at the saturation temperatures corresponding to 1 atmosphere pressure, i. e. atmospheric dew points. The line labeled "saturated liquid" shows the enthalpies of liquid mixtures at the saturation temperatures corresponding to 1 atmosphere pressure, i. e. atmospheric bubble points. The family of curves below the saturated liquid line, sloping downward to the right, are the liquid isotherms which show the enthalpies of liquid mixtures at the temperatures indicated. Note that the enthalpy scale appearing on the right is for use with the saturated vapor line and is not a continuation of the scale on the left which is for liquids.

The lines labeled "equilibrium line" and "conjugate line" each may be used to determine the composition of saturated liquids and vapor which may exist under equilibrium at 1 atmosphere pressure and various temperatures.[1, 4, 5] The "equilibrium line" is the familiar "x-y" plot. A 45° line is included for convenience in constructing the equilibrium tie lines. An equilibrium tie line connects a saturated liquid composition with the corresponding equilibrium vapor composition. In order to locate a tie line, the composition of the liquid is located on the base of the diagram. The vertical ordinate is followed from this point to the "saturated liquid" line. The intersection of the ordinate with the "equilibrium line" is projected horizontally to the 45° line and thence vertically to the "saturated vapor" line. The tie line is drawn from this point to the value of liquid composition of the "saturated liquid" line.

In order to locate a tie line from the "conjugate line," the liquid composition is projected vertically to the conjugate line and thence horizontally to the "saturated vapor" line.

Figure 2 shows the enthalpy of the liquid and vapor phases on the same scale with tie lines. The family of curves in the two phase region, sloping downward to the right, show the weight-percent liquid existing at equilibrium. The family of curves sloping downward to the left show the equilibrium tie lines for various temperatures.

The dotted lines at the bottom of the diagram are the liquid isotherms. The dotted lines at the top of the diagram are three vapor isotherms. The constant-boiling mixture, 95 percent ehtanol, is indicated as a vertical dashed line. Figure 2 is directly applicable to vaporization calculations.

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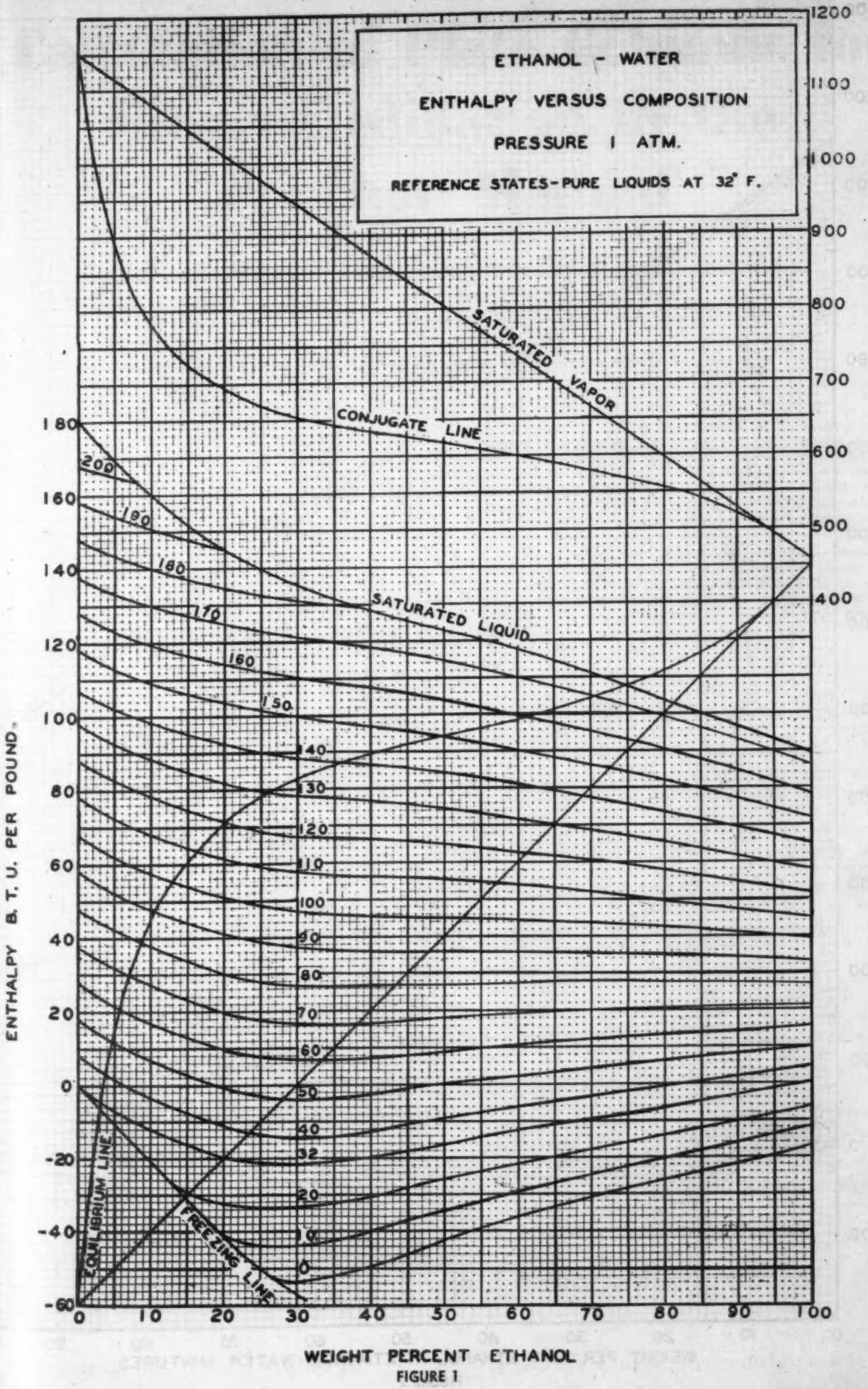
ETHANOL - WATER
ENTHALPY VERSUS COMPOSITION
PRESSURE 1 ATM.
REFERENCE STATES - PURE LIQUIDS AT 32° F.
SATURATED VAPOR
CONJUGATE LINE
SATURATED LIQUID
EQUILIBRIUM LINE
FREEZING LINE
200
180
160
140
120
100
90
80
70
60
50
40
32
20
10
0
ENTHALPY B.T.U. PER POUND
WEIGHT PERCENT ETHANOL
1200
1100
1000
900
800
700
600
500
400
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
0
10
20
30
40
50
60
70
80
90
100

FIGURE 1

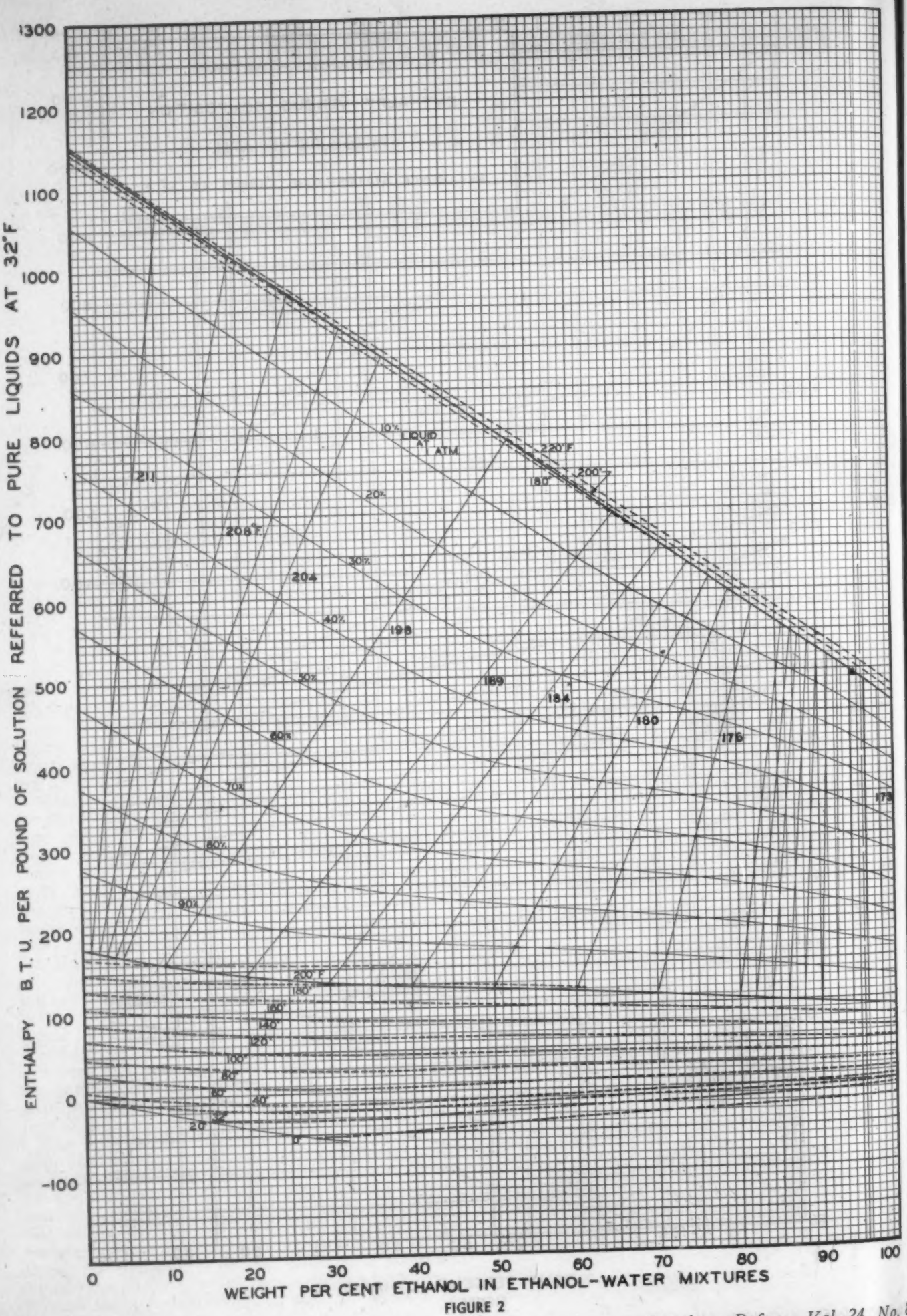
ENTHALPY B.T.U. PER POUND OF SOLUTION REFERRED TO PURE LIQUIDS AT 32°F
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100
0
10
20
30
40
50
60
70
80
90
100
WEIGHT PER CENT ETHANOL IN ETHANOL-WATER MIXTURES
LIQUID AT 1 ATM.
10%
20%
30%
40%
50%
60%
70%
80%
90%
220°F
200°
180°
212
208°F
204
198
189
184
180
176
200°F
180°
160°
140°
120°
100°
80°
60°
40°
32°
20°
0°

FIGURE 2

Calculation of Plate Columns for Binary Distillation by the Ponchon Method

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THE theory of the Ponchon method for computing plate columns is presented. The concept of addition and difference points eliminates the necessity for involved algebraic manipulation regardless of the complexity of the operation under consideration. The application of the theory to specific example problems include simple columns, multiple feeds, multiple products, entrainment, plate efficiency, open steam and side stream recirculation.

The first section of this paper deals with the fundamental theory and its application to the calculation of simple columns. The second section which will appear in the next issue of Petroleum Refiner deals with special applications such as open steam, multiple feed and multiple product columns.

THE Ponchon[3] method for calculating plate columns may be appiled to numerous relatively complicated distillation problems, such as multiple-feed columns involving entrainment. These applications require only simple graphical constructions based on simple theory, obviating the necessity of using any complex equations. The resulting diagrams, in addition to giving the number of equilibrium plates required, facilitate greatly the calculation of heat transfer in the condenser and still, the vapor and liquid flow rates from any plate, the relation between "internal" and "external" reflux and other items that are relevant to the design of columns. The method is rigorous because it incorporates an energy balance for each plate. In spite of these important advantages, the method has been criticized as "lacking the clarity and simplicity desired," and numerous complex equations have been used to modify the approximate McCabe-Thiele method in order to obtain the accuracy inherent in the Ponchon method.[1]

Previous discussions have presented the Ponchon method by an algebraic approach that by its nature is limited practically to simple distillation problems[2,5] or by a somewhat complicated concept of "net flow."[4] As a result an important chemical engineering tool of general application to the calculation of equilibrium stage unit operations has been neglected.

The purpose of this paper is to clarify the theory and applications of the Ponchon method by solving a number of specific distillation problems, using the enthalpy-composition data presented in the preceding article.

Material and Energy Balances

Material and energy balances are basic to the design of plate columns and must be made repeatedly around many parts of a column. For a binary system, these material and energy balances can be made by drawing a straight line on an enthalpy-composition diagram.

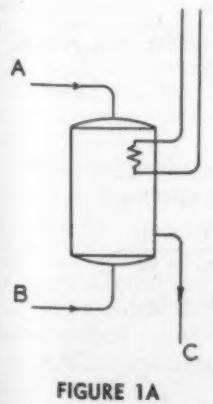


FIGURE 1A

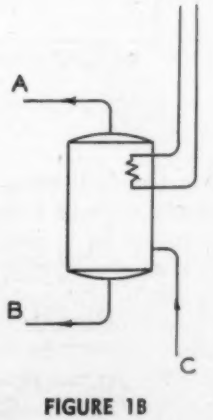


FIGURE 1B

In the operation shown in Figure 1a, streams A and B, containing weight fractions x_a and x_b of the more volatile component, and having enthalpies H_a and H_b, Btu per pound, flow into a vessel where they are mixed continuously. Stream C, containing weight fraction x_c of the more volatile component, and having an enthalpy H_c, Btu per pound, is withdrawn so that steady flow conditions exist. The quantities flowing per unit time of the three streams are A, B, and C pounds per hour respectively.

By a material balance around the vessel,

$$A + B = C \tag{1}$$

and by a more volatile component balance,

$$Ax_a + Bx_b = Cx_c \tag{2}$$

By an energy balance under steady flow conditions,

$$\Delta H + \Delta X + \Delta u^2/2g = q - w \tag{3}$$

If there is no heat transfer to or from the fluids in the vessel, $q = O$. If there is no shaft work done on or by the fluids, $w = O$, and if velocity and gravitational effects may be neglected, $\Delta u^2/2g = O$, and $\Delta x = O$. Therefore, $\Delta H = O$ and

$$CH_c - AH_a - BH_b = 0 \tag{4}$$

By substituting the value of C, given by Equation (1) in Equations (2) and (4),

$$\frac{A}{B} = \frac{x_c - x_b}{x_a - x_c} = \frac{H_c - H_b}{H_a - H_c} \tag{5}$$

and rearranging Equation (5)

$$\frac{H_b - H_c}{x_b - x_c} = \frac{H_c - H_a}{x_c - x_a} \tag{6}$$

The points a, b, and c, representing the enthalpies

and compositions of streams A, B, and C, are plotted on an enthalpy-composition diagram in Figure 2. The term $(H_b - H_c)$ of Equation (6) is represented by the vertical distance from point b to point c. The term $(x_b - x_c)$ is represented by the horizontal distance from point b to point c. The term $(H_b - H_c)/(x_b - x_c)$ is the slope of the straight line connecting points b and c. By Equation (6), this slope is equal to the slope of the straight line connecting points c and a, and since both lines pass through the point c, the three points a, b and c define one straight line. The ratio of distances between the three points a, b, and c are equal to the ratio of the quantities of the three streams A, B, and C. By Equation (5),

$$\frac{A}{B} = \frac{bc}{ac} \; ; \; \frac{A}{C} = \frac{bc}{ab} \; ; \; \frac{B}{C} = \frac{ac}{ab} \qquad (5a)$$

The straight line, abc, of Figure 2 is the graphical solution of the energy and material balances expressed by Equations (1), (2) and (4), and can be used instead of the equations for any purpose.

If the quantities, compositions, and enthalpies of streams A and B are known, the enthalpy and composition of stream C can be calculated from Equations (1), (2), and (4), or can be determined graphically by locating the point c on the straight line ab of Figure 2, so that the ratio of the distances, bc/ac, is equal to the ratio, A/B, of the feed streams. Similarly, if the enthalpies, and compositions of streams A and B are known and either the enthalpy or composition of stream C is known, the other property of stream C may be read directly from the straight line ab and the quantities of the three streams may be determined by evaluating the ratios of the distances as indicated by Equation (5a).

When two streams, A and B, are added, the point, c, representing the product stream C, will lie on the straight line ab and nearer to the stream present in the larger amount. In such cases, the point c is called an "addition point."

The point, c, represents the sum of streams A and B flowing into the vessel of Figure 1a or into any vessel, even though a stream C is not produced. If the streams A and B were processed in a vessel to produce three dissimilar streams, D, E, and F, under steady flow conditions, the point, c, would represent not only the sum of streams A and B flowing into the vessel, but also the sum of the streams D, E, and F, leaving the vessel.

In the continuous process shown in Figure 1b, stream C is being separated into two dissimilar streams A and B under steady flow conditions. The process may be considered as the separation of stream C to produce streams A and B, or, as the subtraction of stream A from stream C to produce stream B, or, as the subtraction of stream B from stream C to produce stream A. In any case, the process is identical to the addition of streams A and B to produce stream C (Figure 1a) except for the reversal of the directions of flow, and the relations expressed by Equations (1) through (6) apply. Therefore, the same straight-line relationship on the enthalpy-composition diagram is applicable, and Figure 2 represents the subtraction of stream A from stream C to produce stream B, and Equation (5a) may be used to determine the relative quantities of the three streams.

When one stream, A, is subtracted from another, C, the point b, representing the properties of the resulting stream, B, lies on the extension of the straight line through points a and c (never between them). In such cases, the point b is called a "difference point," and it will lie nearer the point representing the stream present in the greater amount.

If the quantity of stream A is equal to the quantity of stream C, the difference point, b, lies at an infinite distance from point c, in order that the ratio of the distances $bc/ab = A/C = 1.0$ (Equation 5a). Obviously, a stream B obtained by subtracting stream A from stream C cannot have a weight fraction of more volatile component greater than 1.0 or less than 0.0. Thus, there is a definite limit to the amount of stream A which can be subtracted from stream C to produce a stream B having real properties.

However, the point b represents the difference between streams A and C even though the stream B is not actually produced. Where stream B is not actually produced, the difference point, b, need not represent the properties of a real stream. For example, in the calculation of multiple-feed columns, the point representing the difference between the vapor passing upward and the liquid flowing downward through the section between the feed plates, often has a composition coordinate of less than 0.0 or greater than 1.0 on the enthalpy-composition diagram.

Heat Transfer Under Steady Flow Conditions

If heat is transferred to the fluids flowing through the mixing vessel shown in Figure 1a, q is no longer zero and Equation (4) becomes

$$CH_c - AH_a - BH_b = q \qquad (7)$$

The quantity of heat transferred to the system (the fluids in flow) may be expressed as a function of the quantity of any one of the streams, or

$$q = AQ_a = BQ_b = CQ_c \qquad (8)$$

The equation of the straight line representing the operation on the enthalpy-composition diagram takes

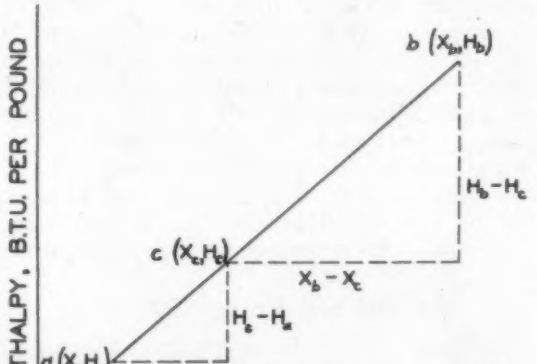


FIGURE 2

one of the following forms, depending upon how the quantity of heat transferred is expressed

$$\frac{(H_a + Q_a) - H_c}{x_a - x_c} = \frac{H_c - H_b}{x_c - x_b} \qquad (9a)$$

$$\frac{H_a - H_c}{x_a - x_c} = \frac{H_c - (H_b + Q_b)}{x_c - x_b} \qquad (9b)$$

$$\frac{H_a - (H_c - Q_c)}{x_a - x_c} = \frac{(H_c - Q_c) - H_b}{x_c - x_b} \qquad (9c)$$

The relationships expressed by Equations (9a), (9b), and (9c) are plotted in Figure 3.

The point b′ (x_b, $H_b + Q_b$) now represents the subtraction of stream A from stream C to produce the stream B plus the energy added to the process per pound of B, and the straight line passes through points a and c, representing streams A and C, as q has been included in b′. Similarly, the point a′ (x_a, $H_a + Q_a$) represents the subtraction of stream B from stream C to produce stream A plus the energy added to the process per pound of A. The point c′ (x_c, $H_c - Q_c$) represents the addition of streams A and B to produce stream C less the energy added to the process per pound of C.

If heat is transferred to the system shown in Figure 1b, Equation (4) becomes

$$AH_a + BH_b - CH_c = q \qquad (10)$$

and depending upon how q is expressed (Equation (8)), the equation of the straight line representing the operation will take one of the following forms:

$$\frac{(H_a - Q_a) - H_c}{x_a - x_c} = \frac{H_c - H_b}{x_c - x_b} \qquad (11a)$$

$$\frac{H_a - H_c}{x_a - x_c} = \frac{H_c - (H_b - Q_b)}{x_c - x_b} \qquad (11b)$$

$$\frac{H_a - (H_c + Q_c)}{x_a - x_c} \qquad \frac{(H_c + Q_c) - H_b}{x_c - x_b} \qquad (11c)$$

The relationship expressed by Equations (11a), (11b), and (11c) are plotted in Figure 4.

The enthalpy coordinate of a point representing the combination of a given entering stream and the energy added to the process is determined by adding the energy per pound of the entering stream to its enthalpy. When the given stream is leaving the process, the energy added to the process per pound of effluent stream is subtracted from its enthalpy.

Applications of the Ponchon Method

The Simple Column

The application of the foregoing concepts to the calculation of an ordinary plate column is shown by the following example:

Example No. 1. A column containing 10 plates and equipped with a still and apparatus for returning reflux is producing a distillate product containing 90 weight-percent ethanol and a bottom product containing 1.0 weight-percent ethanol, from a feed containing 35.0 weight-percent ethanol, balance water. The column operates under a pressure of 1 atmosphere. The feed is introduced into the downspout of the seventh plate at temperature of 183.4° F. and at the rate of 1000 pounds per hour. The distillate product and reflux are withdrawn from the reflux accumulator at 114° F. Reflux is supplied to the top plate of the column at the rate of 1170 pounds per hour. It is desired to compute the over-all plate efficiency, the rate of heat transfer in the still and condenser, and the rate at which vapor is produced from the still.

The enthalpy-composition diagram for the system ethanol-water at 1 atmosphere is presented in Figures 1 and 2 of the preceding paper. The saturation lines of these charts are shown in Figure 5. The equilibrium tie lines and the liquid and vapor isotherms are omitted for clarity. From Figure 2 the feed is a mixture of liquid and vapor having an enthalpy of 150 Btu per pound and is represented by a point lying on the equilibrium tie line for 183.4° F. at $x_F = 0.35$. The feed is represented by point F in Figure 5. The bottom product, withdrawn as a saturated liquid from the still is represented by the point B on the saturated liquid line and the distillate product and reflux are both represented by the point D the enthalpy coordinate of 50 Btu per pound being located by the 114° F. isotherm of Figure 1. The overhead vapors leaving the top plate, have the same composition as the distillate product and are represented by the point V_1 on the saturated vapor line, directly above point D.

In order to calculate the number of equilibrium plates required to effect the above separation, the difference points d and d′ that represent the difference

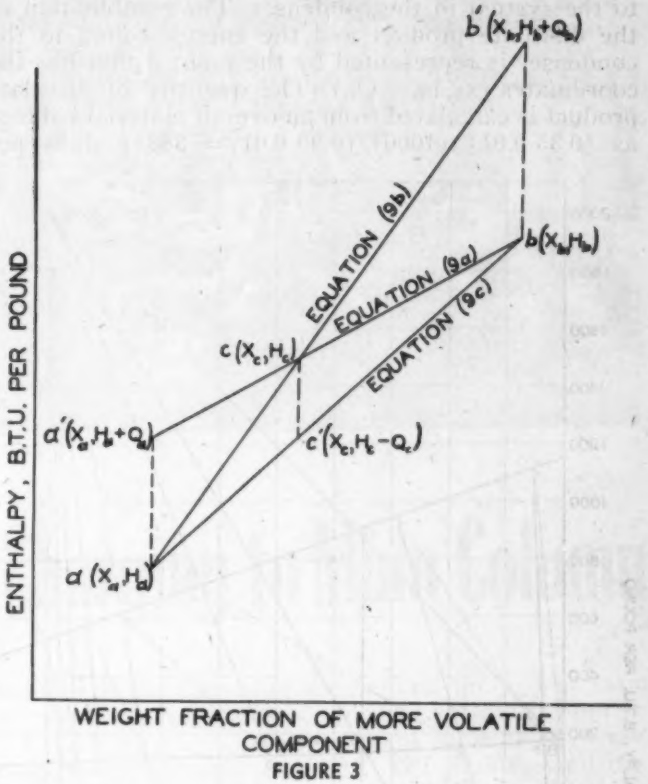


FIGURE 3

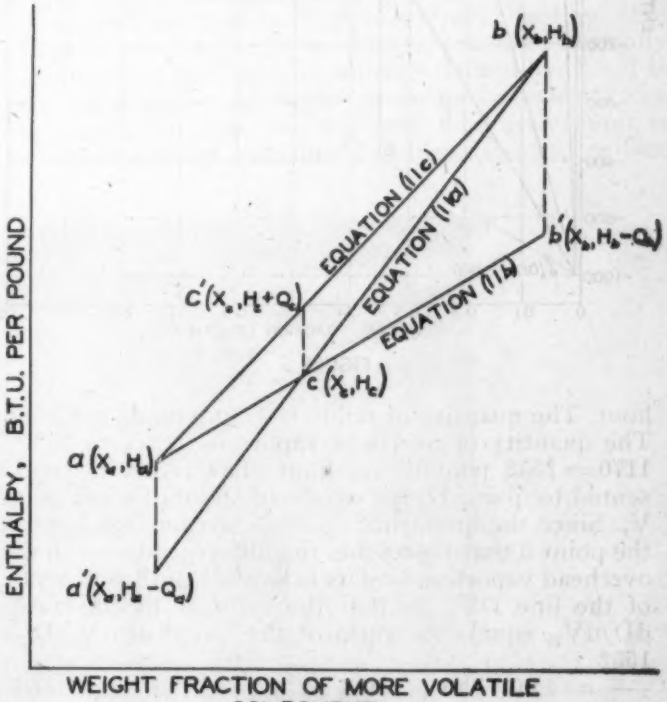


FIGURE 4

between liquid and vapor passing one another in the rectifying section and in the stripping section must be located on the diagram.

Considering the rectifying section, the difference between the liquid and vapor passing one another

between any two plates of the section is equal to the difference between liquid and vapor passing one another between any other two plates under steady flow conditions. This difference is equal also to the difference between the overhead vapors and reflux passing one another above the top plate and to the distillate product leaving the system minus the energy added to the system in the condenser. The combination of the distillate product and the energy added in the condenser is represented by the point d that has the coordinates (x_D, $h_D - Q_D$). The quantity of distillate product is calculated from an overall material balance as (0.35-0.01) (1000)/(0.90-0.01) = 382 pounds per

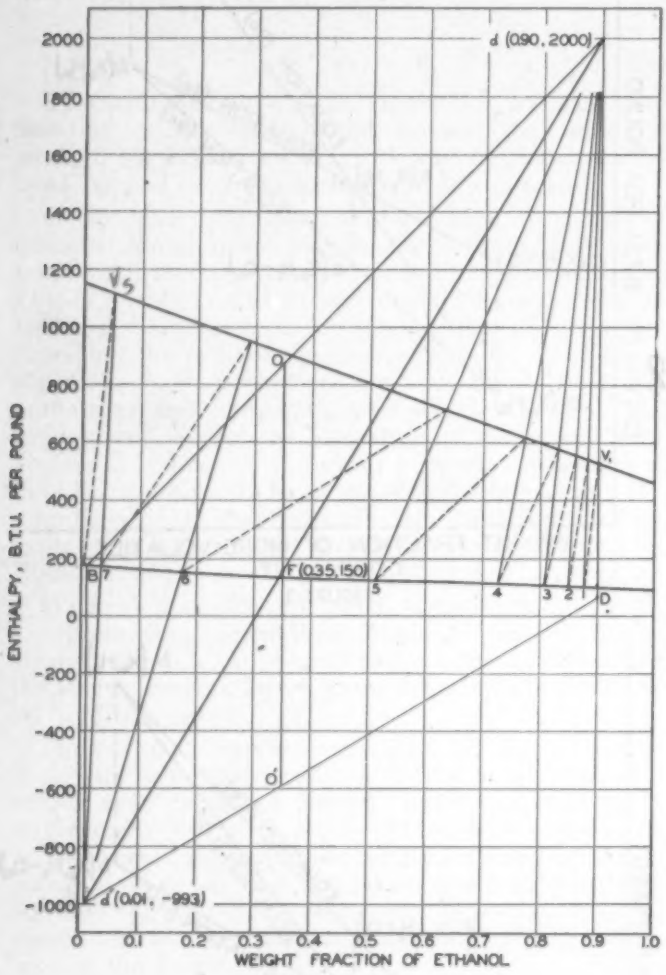


FIGURE 5

hour. The quantity of reflux is 1170 pounds per hour. The quantity of overhead vapors is therefore 382 + 1170 = 1552 pounds per hour. The reflux is represented by point D, the overhead vapors by the point V_1. Since the quantities of these streams are known, the point d that represents the difference between the overhead vapors and reflux is located on the extension of the line DV_1, so that the ratio of the distances dD/dV_1, equals the ratio of the quantities $V_1/D = \frac{1552}{382} = 4.06$. The point d so located has the coordinates (0.90, 2000). It is clear that the reflux ratio, defined as the ratio of the quantity of reflux to the quantity of distillate product is equal to the ratio of the distances $dV_1/DV_1 = 3.06$, since the point d represents a *quantity* equal to the quantity of distillate product.

The difference between liquid and vapor passing one another between any two plates of the stripping section is equal to the bottom product withdrawn from the still less the energy added in the still and is represented by point d' having the coordinates (x_B, $h_B - Q_B$). Furthermore since the feed, F, entering the column equals the sum of (1) the distillate product less the energy added in the condenser, represented by point d (x_D, $h_D - Q_D$) and (2) the bottom product minus the energy added in the still, represented by point d' (x_B, $h_B - Q_B$); the points d, F, and d' lie on a straight line. In this case the point d' is located by extending the line dF to the value $x_B = 0.01$, $h_B - Q_B = -993$.

The number of equilibrium plates are determined by a plate-to-plate construction beginning with the point V_1 representing the vapors leaving the top plate. The liquid, L_1, on plate 1 is located by the equilibrium tie line from point V_1. The point V_2 on the saturated vapor line representing the vapors rising from the second plate and passing L_1, must lie on the straight line V_2L_1d, since point d represents the difference between liquid and vapor passing one another between plates of the rectifying section. Thus, the point V_2 is located by the intersection of the line dL_1 with the saturated vapor line. The liquid L_2 on the second plate is located by the equilibrium tie line from V_2. This procedure is followed until the feed-plate liquid is determined. Since the vapors rising to the feed plate pass the feed-plate liquid in the stripping section, the point d' is used to continue the construction until the bottom-product composition is reached.

A difficulty arises in this problem because while the actual feed-plate location is known, the equilibrium feed-plate location is not known because plate efficiency is not known. It is necessary, therefore, to assume an equilibrium feed-plate location, calculate the number of equilibrium plates in the column and then use the resulting plate efficiency to check the assumed equilibrium feed-plate location.

The final trial shown in Figure 5, shows that 7.8 equilibrium plates are required to effect the separation when the feed is introduced on the 5.5 equilibrium plate. The still is assumed to be equivalent to one equilibrium plate, leaving 6.8 equilibrium plates in the column and giving an overall plate efficiency of 68 percent. The feed-plate location is on the 5.5/0.68 = 8th plate from the top of the column.

The energy added in the condenser is $Q_D = 2000 - 50 = 1950$ Btu per pound of distillate and the energy added in the still is $Q_B = 993 + 179 = 1172$ Btu per pound of bottom product. Therefore, the rate of heat transfer in the condenser is (1950) (618) = 725,000 Btu per hour. The still heat transfer per pound of feed may be evaluated also by locating the point O on the line Bd, directly above point F. The distance OF gives the still heat transfer, Btu per pound of feed, since the feed plus the energy added in the still, represented by point O, must equal the sum of (1) the bottom product, B and (2) the distillate product less the energy added in the condenser, represented by point d. Similarly, the heat transferred in the condenser, Btu per pound of feed is the distance FO', O' lying directly below F on the line d'D.

The point V_s represents the vapor leaving the still and passing the liquid on the bottom plate, L_7. Since the point d' represent a *quantity* of material equal to the quantity of bottom product, the ratio V_s/B is equal to the ratio of the distance $d'L_7/V_sL_7 = 5.63$ and thus $V_s = (5.63)\ (618) = 3480$ pounds per hour.

To be concluded in September, including complete bibliography.

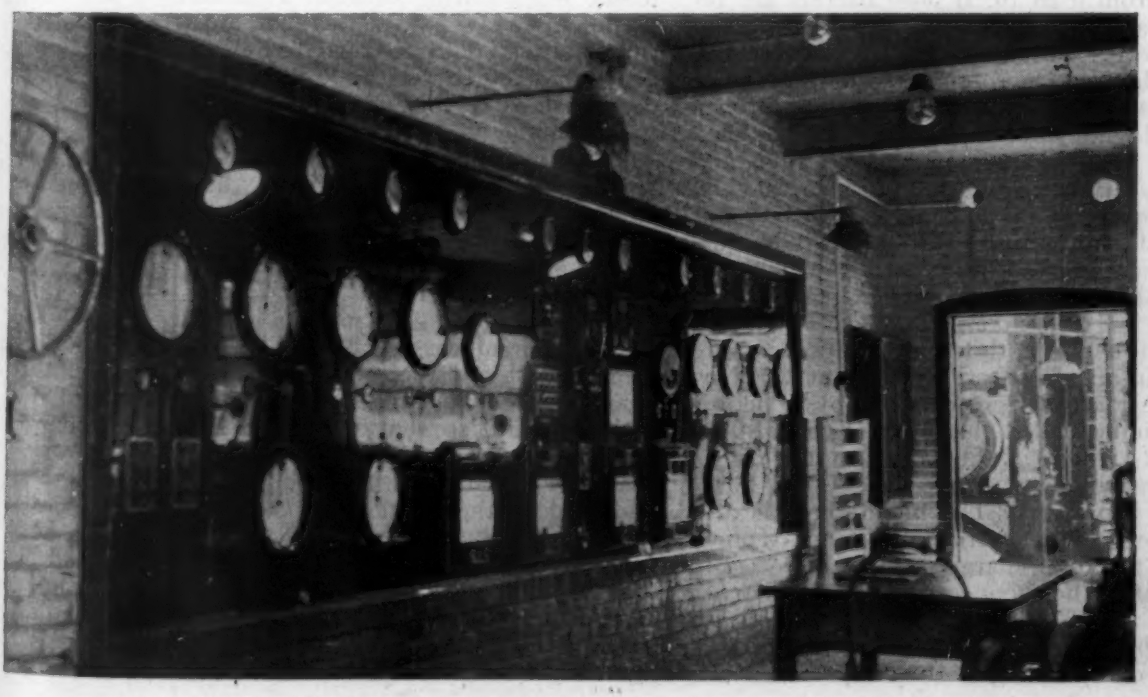
Among this group of process pumps are two handling separate grades of crude oil being blended for charge to main column.

Two Crudes Blended While Charging to Main Column

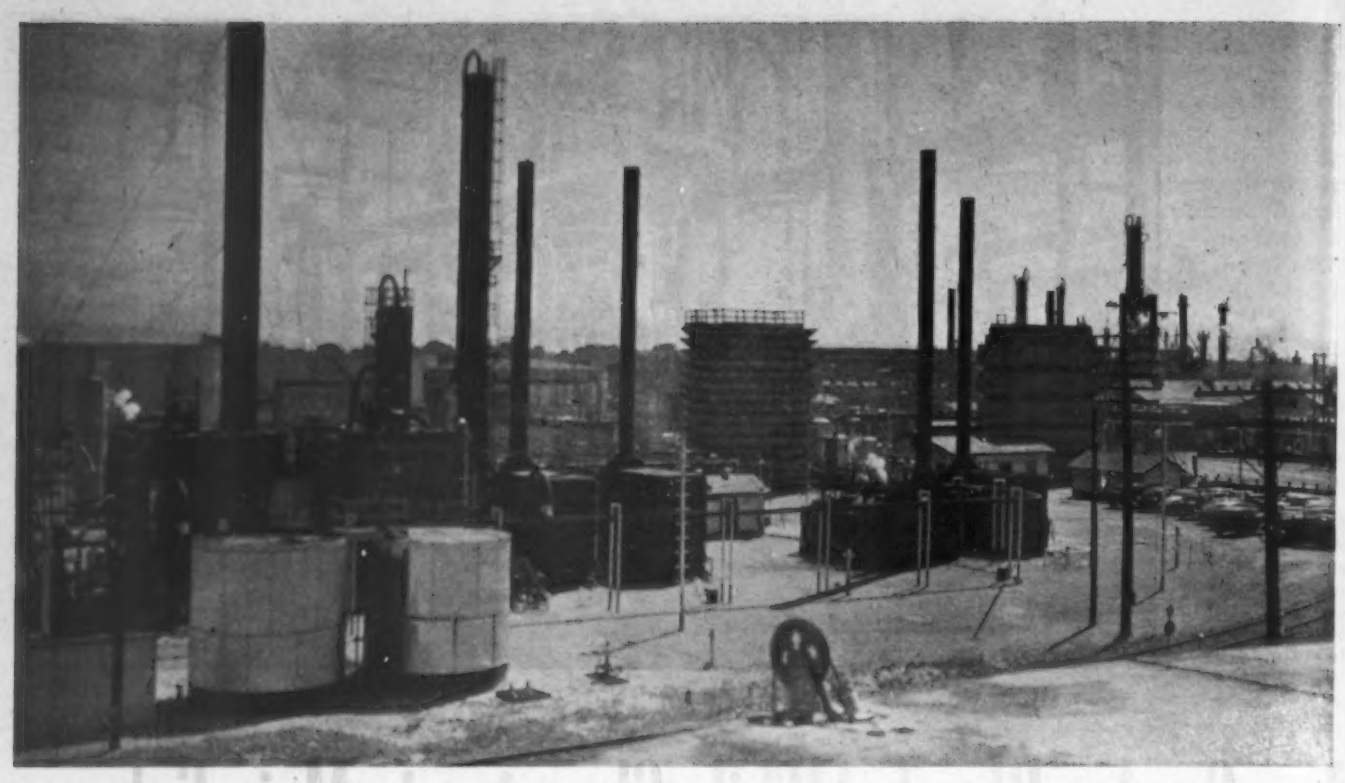
FOR charging two types of crude oil into the main column at the Bakersfield plant of Mohawk Petroleum Corporation, E. R. Shelton, assistant superintendent, worked out a method of blending while pumping. The method consists of operating two charge pumps simultaneously, with the controller set to discharge at the required rate. One pump bucks the other, which slows its delivery, permitting the second pumpto fill its part of the predetermined total.

This adaptation of blending while pumping eliminates use of mixing tanks ahead of charging. Manipulation of the pumps is simple, and the proper ratio of two crudes can be occomplished within an hour.

Crude oils available to this plant come chiefly from the Rio Bravo deep pool, 38.8 API gravity, and the older Weed Patch field, around 25 API gravity. Each is separately stored. Equipment for charging consists of two duplex steam pumps, one used normally as an active unit and the other as stand-by. Each is equipped with a controller so an exact quantity can be charged to the main column. The active unit is controlled by an instrument, which is set to deliver



Some of the controllers in this arrangement are used to handle the crude charge while blending two oils.



Mohawk Petroleum Corporation's plant at Bakersfield, California; crude and cracking units in foreground and high-octane plant in distance.

the overall plant charge. The chart on this controller usually draws a consistent circle.

Orifice fittings are on the main charge line which controls the pump handling straight crude until a blend is desired. There is a similar orifice fitting on the discharge line of the stand-by pump. Suction manifolds permit use of either pump on either crude.

When, for instance, the processing schedule calls for 3600 barrels daily of Rio Bravo crude, the normally active pump is used with its control set to deliver that amount. When the plant schedule calls for a blend of the two crudes, both pumps are used, each taking suction from a different tank.

The instruments use the standard flow-meter chart with divisions from 0 to 10. If 3600 barrels are required as the plant charge, the recorder on the main charge line operates with the pen at approximately 4.9, which would vary as to the size of the orifice plate. With this setting, quantity of oil passing through the orifice would not exceed 3600 barrels per day.

The stand-by pump chart is of the same type, and a blend chart is furnished the operators so that, by setting the stand-by pump into action, the amount of crude pumped by it will pass through its individual orifice fitting and the main orifice fitting which controls the normally active pump. When the required blend of crude is 1200 barrels of Weed Patch and 2400 barrels of Rio Bravo, the total quantity passing through the main-line orifice still remains at 3600 barrels. Setting the controller on the stand-by to deliver 1200 barrels is indicated on the recorder chart at approximately 6.2, which is the point on the Weed Patch chart conforming with one-third Weed Patch and two-thirds Rio Bravo. The blend chart is also extended to show at what setting the stand-by pump is to operate if the total charge is to be observed in composite gravity. The same setting for 1200 barrels of Weed Patch and 2400 barrels for Rio Bravo also indicates that the charge will have a gravity of 33.7.

The process of operating both pumps takes this form. When the normally active pump is handling 3600 barrels of oil, it cannot exceed this quantity unless its controller is changed. If no more than 3600 barrels of oil can pass through its orifice without being reflected in the operation of the pump, when an extraneous quantity starts flowing through the orifice under identical pressure the normally active pump must reduce its delivery by the amount of extraneous oil passing through the orifice.

Therefore, to obtain the desired blend, the stand-by pumps bucks the discharge of the normally active pump with 1200 barrels, automatically slowing down the normally active pump to 2400 barrels, so that only 3600 barrels of oil flows through the charge line to the fractionating column. This method has been used long enough to show that any type of blend can be used, even to 2400 barrels of Weed Patch and only 1200 barrels of Rio Bravo, all of which is done without reserve tankage and without disturbing the main storage of either type of crude.

When making the blend, the stand-by pump is increased in speed at approximately 5 minute intervals so as to provide sufficient time for the main column to adjust itself to the changed composition of the charge. It usually requires one hour to bring the charge to the full blend.

The actual intimate mixing and blending of the two grades of crude takes place in the main line orifice fitting and the following equipment and interchangrs set in the line between the pumps and the main column, so that when the composite charge enters the inlet nozzle the blend is complete.

Before the change was made to include this method of blending the charge, the single recording flow-meter instrument was connected so that the normally active or stand-by pump could be operated by simply changing the gate setting. The additional equipment necessary for the completed installation called for only one more flow-meter controller and the orifice on the discharge of the stand-by pump.

Thermobarometer

Quick and Exact Conversion of Gas Volumes into Weight

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THE function of the thermobarometer is to assist in the correction of gas volumes obtained in gas analytical determinations to normal temperature and pressure. It includes corrections due to temperature and pressure changes as well as allowing for the vapor pressure of the confining liquid in the gas buret. A known volume of air (100 cc. at NTP in the present instrument) expands or contracts with the continuous changes in atmospheric pressure and temperature of the room in which the gas determinations are carried out. If the air in the thermobarometer and the analysis gas are in equilibrium with the atmospheric pressure and at the same temperature, the volume occupied by the air is substituted in Equation 1 as thermobarometer reading. The necessity for equality in temperature requires that gases evolved in exothermic analytical reactions be allowed sufficient time to return to room temperature. In contrast to the well-known Lunge or Hempel compensator, only one thermobarometer is necessary for an entire battery of gas burets using identical confining liquids. The conversion of gas volume into weight can be carried out with Equations 1 or 2 and Tables 1 and 2.

In the equation:

$$A = \frac{V \times f \times 10}{T.R. \times W} \qquad (1)$$

or

$$\log A = \log V + \log R.F. + \log f + 1 - \log W \qquad (2)$$

A = weight % of constituent Y (Tables 1 and 2) to be determined analytically
V = gas volume measured at room temperature and prevailing atmospheric pressure
f = conversion factor of gas volume into weight of desired contituent (see Tables 1 and 2 for a number of the more common conversions)
$T.R.$ = thermobarometer reading at room temperature and prevailing atmospheric pressure
W = weight of sample in grams
$\log R.F.$ = log of reduction factor from Figure 1 for a given thermobarometer reading.

The thermobarometer is drawn to scale in Figure 1. It consists of tube A with stopcock 1 with an upper uncalibrated part of 90-cc. volume and the lower calibrated part of 35-cu. cm. volume subdivided into scale divisions of 0.05 cu. cm. and numbered at each cu. cm. Tube B, open to the atmosphere, is placed as near as possible to tube A, having identical though unnumbered calibration marks. Leveling bulb C is connected with heavy rubber tubing to A and B through stopcock 2. Whenever a thermobarometer reading is to be made, the mercury levels in A and B are equalized by opening stopcock 2 with leveling bulb C in position to receive from or add mercury to tubes A and B. When the mercury levels in A and B are identical, stopcock 2 is closed and the volume reading is substituted in Equation 1.

To adjust the thermobarometer initially, temperature and barometric pressure in the laboratory are determined. Assume that a temperature of 25°C. and a barometric pressure of 720 mm. of mercury exist at the time of adjustment. If dry gases—for instance, nitric oxide in the Lunge nitrometer over mercury—are being measured, 720.0 (pressure scale) in Figure 2 is connected with 25.0 (temperature scale, dry gas) and extended to thermobarometer reading scale. This scale indicates that 100 cc. of dry air at NTP expand to 115.21 at the prevailing pressure and temperature. Air dried with a drying agent, such as phosphorus pentoxide, calcium chloride, etc., is introduced into the dry tube, A, which was initially filled with mercury. Stopcock 1 is closed

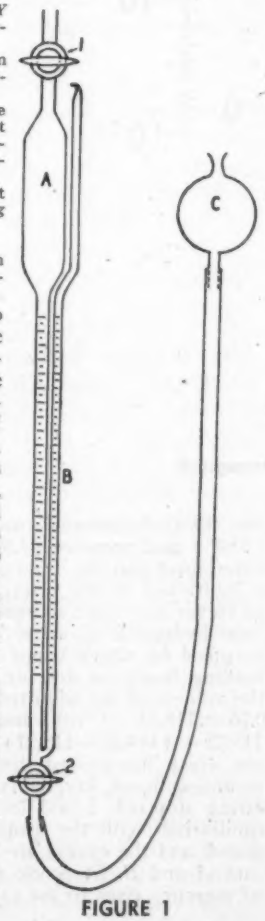

FIGURE 1

TABLE 1
Conversion Table

Conversion Factor, Cc. (NTP) of X into Mg. of Y			
X	Y	Factor	Log Factor
CH_4	CH_4	0.7173	0.8557–1
C_2H_2	C_2H_2	1.172	0.0689
C_2H_2	CaC_2	2.885	0.4601
CO	CO	1.251	0.0972
CO_2	C	0.5396	0.7321–1
CO_2	CH_4	0.7208	0.8578–1
CO_2	CO_2	1.977	0.2961
CO_2	$CaCO_3$	4.496	0.6529
Cl_2	Cl_2	3.220	0.5079
H_2	Al	0.8015	0.9039–1
H_2	Ca	1.787	0.2520
H_2	Fe	2.489	0.3961
H_2	H_2	0.08987	0.9536–2
H_2	K	3.486	0.5423
H_2	Mg	1.084	0.0351
H_2	Na	2.050	0.3118
H_2	Zn	2.915	0.4646
H_2S	H_2S	1.539	0.1873
N_2	$CO(NH_2)_2$[a]	2.956	0.4707
N_2	N_2	1.250	0.0970
N_2	N_2[b]	1.282	0.1080
N_2	NH_3[c]	1.558	0.1927
NH_3	NH_3	0.7711	0.8871–1
O_2	O_2	1.429	0.1550
O_2	Bleaching chlorine in $CaOCl_2$[d]	3.167	0.5006
O_2	H_2O_2[e]	1.518	0.1813
O_2	H_2O_2[f]	3.036	0.4823
SO_2	S	1.465	0.1657
SO_2	SO_2	2.926	0.4663

Factors in Table 1 are arranged in alphabetical order of the obtained gas and then of the analyzed substances.

[a] Reaction with sodium hyprobromite (see [b]). Low yield of 91 percent due to incomplete reaction is considered in factor.

[b] Ammonium compounds with sodium hypobromite:

$$2NH_3 + 3NaOBr = N_2 + 3NaBr + 3H_2O$$

[c] Ammonia determination in ammonium compounds as in [b].

[d] Bleaching chlorine in bleaching powder with hydrogen peroxide:

$$C_aOCl_2 + H_2O_2 = O_2 + CaCl_2 + H_2O$$

[e] Hydrogen peroxide analysis with reaction [d] or with:

$$5H_2O_2 + 2KMnO_4 + 3H_2SO_4 = 5O_2 + 2MnSO_4 + K_2SO_4 + 8H_2O$$

[f] Hydrogen peroxide analysis by catalytic decomposition with Pt, Vd, or Co compounds:

$$2H_2O_2 = O_2 + 2H_2O$$

TABLE 2
Conversion Table*

Conversion Factor, Cc. of NO (NTP) into Mg. of Y			
	Y	Factor	Log Factor
NO	Dinitrotoluene	4.066	0.6092
NO	Glycerol trinitrate	3.380	0.5289
NO	HNO_3	2.814	0.4493
NO	KNO_2	3.800	0.5798
NO	KNO_3	4.515	0.6547
NO	N	0.6256	0.7963–1
NO	NO	1.340	0.1271
NO	NO_3	2.760	0.4423
NO	N_2O_3	1.697	0.2298
NO	N_2O_5	2.412	0.3824
NO	NH_4NO_3	3.575	0.5533
NO	$NaNO_2$	3.082	0.4484
NO	$NaNO_3$	3.796	0.5793
NO	Picric acid	3.410	0.5328
NO	SO_3NH	5.675	0.7540
NO	TNT	3.382	0.5291

* Data are in alphabetical order of substance to be analyzed. For other analyses and, for instance, for determination of phenylhydrazine by oxidation with Fehling's solution or determination of nitroso groups with phenylhydrazine or of primary amines with nitrous acid made by measurement of nitrogen—the conversion factors and their logs have to be determined by taking into account the mole weight and the experimental mole volume of the gas developed.

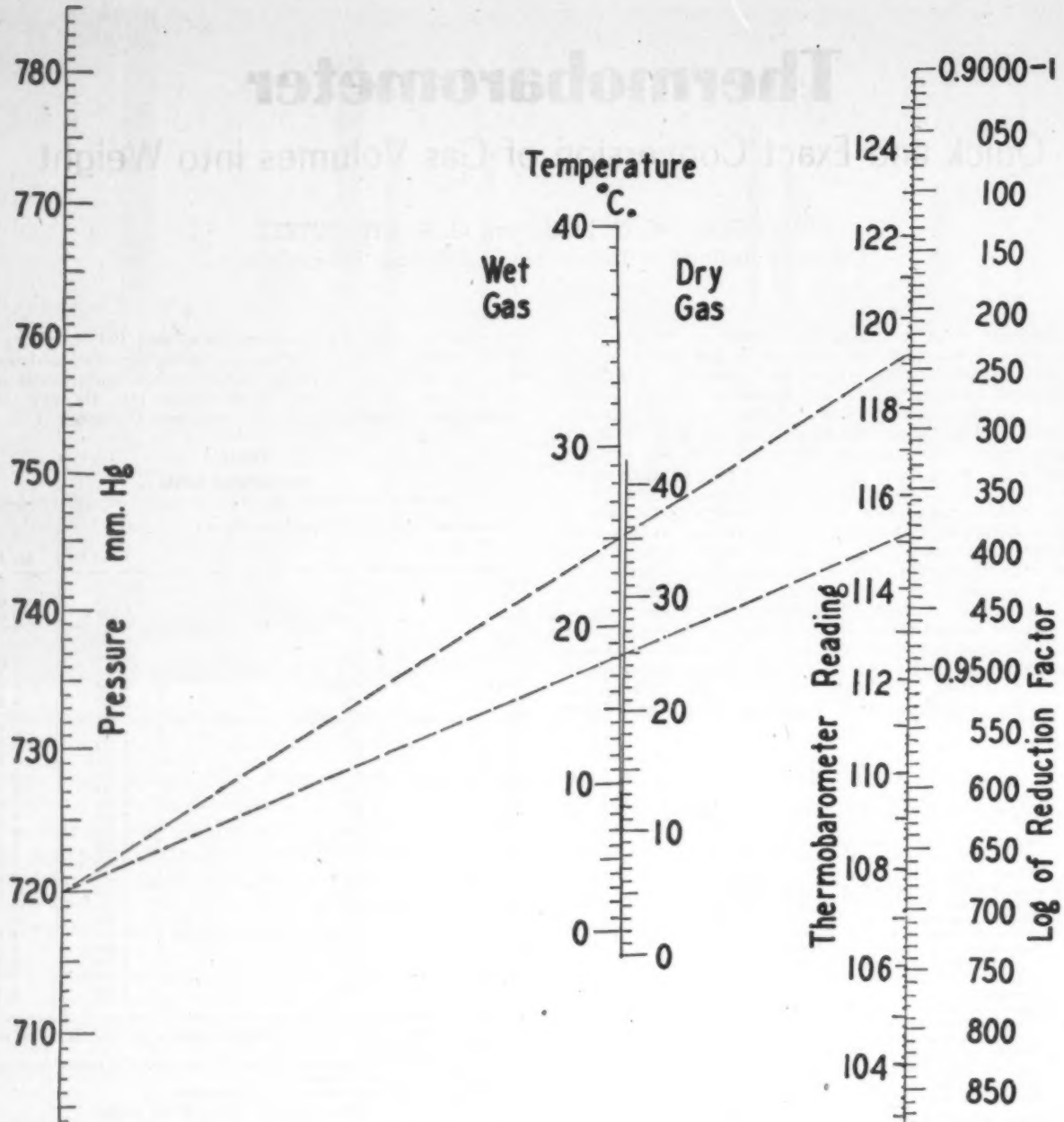

FIGURE 2. Nomograph

permanently when the mercury in tubes *A* and *B* are level at a scale reading of 115.21.

If the analysis yields gases which are confined over water in the gas buret, the thermobarometer adjustment, for similar temperature and pressure conditions as above, is made by connecting 720.0 (pressure scale) with 25.0 (temperature scale, wet gas) and extending to the thermobarometer reading scale at 119.21. To keep the air in *A* saturated with water at all times, one or two drops of water are introduced through stopcock 1. Water vapor-saturated air is introduced into *A* and the mercury in *A* and *B* is leveled at a scale reading of 119.21.

If analyses are carried out where gases—for instance, carbon dioxide—are collected over saturated sodium chloride solution or, for instance, nitrogen over aqueous potassium hydroxide (1 to 2.5) the reduction of vapor pressure of water, due to the presence of electrolytes, must be taken into account. Two drops of liquid of the same composition as the confining liquid are introduced into *A* before the final adjustment is made. The volume of air to be introduced into *A* is calculated as follows:

Since $v.p._{NaCl_{sat.}} = 0.76\, v.p._{H_2O}$

and $v.p.\ KOH/H_2O\ (1\text{ to }2.5) = 0.65\, v.p.\ H_2O$

the thermobarometer reading for the prevailing temperature (25.0°) and pressure (720.0 mm.) for both dry and wet gas is determined and the difference between thermobarometer readings is multiplied by the fractional reduction in water vapor pressure (0.76 for saturated sodium chloride solutions and 0.65 for potassium hydroxide to water 1 to 2.5). This represents the volume occupied by water vapor and is added to the thermobarometer reading based on dry air. Thus for saturated sodium chloride, the volume of air admitted to *A* is $115.21 + (119.21 - 115.21) \times 0.76 = 118.25$ cu. cm., and for potassium hydroxide (1 to 2.5) $115.21 + (119.21 - 115.21) \times 0.70 = 118.01$ cu. cm. An excess of air which has passed through a washing bottle filled with the confining liquid, say 130 cu. cm., is introduced into *A* by manipulating stopcock 2 and leveling vessel *C*, allowed to come into equilibrium with the drops of confining liquid previously introduced, and the excess air expelled by gradual inflow of mercury into *A* and *B*. Stopcock 1 is permanently closed when the level of mercury rises to the calculated value.

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Determination of Phosphorus In Lubricating Oils

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A METHOD is described for the determination of pentavalent phosphorus in new and used lubricating oils containing less than 0.5 percent phosphorus, without interference from lead, iron, copper, aluminum, tin, zinc, cadmium, barium, silicon, magnesium, calcium, sulfur, or chlorine. In the range from 0.001 to 0.1 percent phosphorus, the method is accurate and reproducible to 0.001 percent. The procedure is also applicable, with less precision and accuracy, to the determination of the phosphorus content of lubricating-oil additives, except volatile derivatives of phosphine or phosphorous acid.

THE advent of lubricating-oil additives containing organic phosphorus compounds has created the need for an accurate method for determination of the phosphorus content of new and used lubricating oils. It is generally known that as little as 0.001 percent phosphorus sometimes significantly changes the wear characteristics of a lubricating oil. Thus it was important to producer and consumer alike to determine the phosphorus content of lubricants, accurately and reproducibly. A search of the literature revealed that an acceptable standard method was lacking; therefore an investigation was made to find a method acceptable for standardization purposes. The development of the method involved: (1) — development of a scheme for complete decomposition of the organic matter with quantitative retention of the phosphorus as the inorganic phosphate salt, and (2) — selection of a procedure for determining the quantity of the recovered phosphorus.

The usual methods for the decomposition of organic matter to be considered are Carius digestion,[16] oxygen bomb combustion,[10] sodium peroxide bomb combustion[8], sulphuric acid-nitric acid digestion, open ignition, and ignition in the presence of an alkali salt [3,7,11]. A sulfuric acid-nitric acid digestion in an open beaker usually is not satisfactory, as there is always the danger of loss of volatile organic phosphorus compounds. Furthermore, only a very limited amount of sample can be decomposed by this method. Acid digestion can be accomplished in a Kjeldahl type flask but is very slow and the large quantities of reagents needed to decompose several grams of sample introduce undesirable amounts of impurities. The Carius digestion, while quite satisfactory for organic compounds containing several percent of phosphorus, is useless in the analysis of lubricating oils of low phosphorus content, because only small quantities of organic material can be safely decomposed in this manner and because some metals tend to interfere in the subsequent analysis. Also, the high concentration of nitric acid is objectionable if the phosphorus is determined by the conventional colorimetric methods. The oxygen bomb combustion[10], while probably the fastest and most convenient method of decomposition, gives low and erratic results in some cases and is limited to rather small samples. The sodium peroxide bomb combustion is also limited to a rather small sample, and the difficulty in completely decomposing excess sodium peroxide makes it undesirable if a colorimetric method of analysis is subsequently employed.

Open ignition, or dry ashing, has the advantage of allowing the use of a larger sample than can be tolerated by the above mentioned procedures but, as in wet oxidation, there is danger of loss of organic phosphorus compounds. Von Kolnitz and Remington[12,17] report a method whereby up to 100 grams of vegetable matter can be decomposed with the use of an enclosed oxygen torch of special design. Some methods require the addition of zinc oxide[8] or sodium naphthenate[7] to the oil prior to ignition in order to eliminate the loss of phosphorus by retaining it as the alkali phosphate. However, a method[11] employing both zinc oxide and sodium peroxide during the ignition appears particularly advantageous for two reasons: (1) it supplies oil-soluble alkali and metal to help retain the phosphorus, and of equal importance, (2) it supplies a reactive oxidation medium to aid in the decomposition of the organic matter and in the conversion of the phosphorus to the alkali phosphate. It is this latter combination of oxides that is employed in the present method.

At least four basic methods of analysis, each with numerous modifications, can be used in the final determination of the inorganic phosphate, e.g., colorimetric, gravimetric, centrifugal, and titrimetric. Of the four, the colorimetric procedures appear most frequently in the literature. The most recent colorimetric procedures utilize the formation of ammonium vanadiomolybdate[1,9,18] or the molybdenum blue complex[2,3,4,6,14,15] by the phosphorus in the presence of various reducing agents, particularly stannous chloride. Our experience in the use of stannous chloride as a reducing agent indicates that the color comparison solutions tend to fade and that certain elements (e.g., tin and silica) sometimes interfere. However, the procedure is rapid, and under favorable conditions is applicable to very low concentrations of phosphorus. The method of Zinzadze[20] employing a reduced molybdenum reagent appears to be the most successful colorimetric method. This procedure, like the stannous chloride procedure, is rapid and sufficiently sensitive to allow use of small samples. How-

ever, the Zinzadze method also shows a fading of the color comparison solutions in the presence of certain oxidizing materials, such as silicates, nitrates, and peroxides often present after the decomposition of used lubricating oils. Although the Zinzadze procedure can be used satisfactorily in the presence of some of these materials by the addition of sodium bisulfite, it is not applicable in all cases.

Many modern texts and reference books on inorganic analysis suggest the preliminary precipitation of phosphorus as the yellow ammonium molybdiphosphate[19] followed by a double precipitation as the magnesium ammonium phosphate, which is determined gravimetrically. The double precipitation is generally necessary because the high concentration of ammonium salts present during the first precipitation gives a precipitate of indefinite composition. The time required for the three precipitations renders the gravimetric procedure undesirable for the routine determination of phosphorus. Also, the gravimetric procedure is limited to a sample containing more than 3.0 mg. of phosphorus as smaller amounts give unreliable results unless micro technique and equipment are used.

An interesting method of determining the inorganic phosphorus is the measurement of the volume of the ammonium molybdiphosphate precipitate obtained in a centrifuge tube.[7, 10] Only one precipitation is necessary in this case, and the volumetric measurement of the precipitate is very rapid. However, this method sometimes gives erratic results even when the conditions are carefully standardized. The poor precision can be attributed partly to the difficulty of reading the final volume of the centrifuged precipitate because of its beveled, uneven surface. Furthermore, it is difficult to keep the inner surfaces of the centrifuge tube sufficiently clean and smooth to prevent the precipitate from clinging to the sides of the tube. However, with experience, the centrifugal method of analysis may prove useful for routine work in some laboratories, especially those possessing high-speed centrifuges.

Generally, it is desirable to determine the phosphate ion by titrimetric methods. Two methods find common use: (1) precipitation of the phosphorus as the ammonium molybdiphosphate, reduction of the hexavalent molybdenum with zinc, and titration of the trivalent molybdenum with standard permanganate solution, and (2) alkalimetric titration of the ammonium molybdiphosphate precipitate. The reduction method is troublesome to use and is time-consuming. The alkalimetric method is in common use because of its simplicity and speed; it is precise and accurate provided care is taken to control precipitation conditions so that a reasonably pure ammonium molybdiphosphate precipitate is obtained.

Recommended Method for Determination of Phosphorus in Lubricating Oils

The following procedure is applicable to the determination of phosphorus in all types of new and used lubricating oils containing 0.001 to 0.5 percent phosphorus. Low results are sometimes found for materials containing derivatives of phosphine or phosphorus acid; however, a large proportion of the phosphorus present is always found regardless of the amount present. It is applicable in the presence of the amounts of metallic elements, sulfur and chlorine, commonly found in new or used oils. By proper selection of sample size, the method is applicable to organic derivatives of pentavalent phosphorus, such as lubricating-oil additives, the relative precision being dependent on the permissible size of sample.

This method is essentially the same as that recently standardized as D-809 by the American Society of Testing Materials.

Outline

The sample, mixed with sufficient oil to give a mixture whose phosphorus content is below 0.1 percent, is mixed with sodium peroxide and zinc oxide. The mixture is heated to 100° C., benzene is added and the resulting mixture allowed to burn. After removal of the residual carbon by ignition, the residue is dissolved in acid, the phosphorus is precipitated as the ammonium molybdiphosphate, and the precipitate is titrated alkalimetrically.

Special Reagents

Ammonium molybdate reagent. Dissolve 100 g. of c.p. ammonium molybdate in dilute ammonium hydroxide containing 80 ml. of concentrated ammonium hydroxide in 400 ml. of distilled water. Prepare the ammonium molybdate reagent immediately before use by pouring one volume of the alkaline molybdate solution into two volumes of 6 to 6.5 N nitric acid, stirring vigorously.

Sodium peroxide, containing less than 0.0005 percent phosphorus.

Zinc oxide, containing less than 0.0005 percent phosphorus.

Oil diluent, containing less than 0.001 percent phosphorus. Refined lubricating oil containing no addition compounds has been found satisfactory.

Sodium hydroxide, standard 0.1 N, carbonate-free.

Nitric acid or sulfuric acid, standard 0.1 N.

Procedure

Introduce weights of sample and oil diluent as specified in the following table into a 25-ml. nickel crucible:

Phosphorus Content	Weight of Sample, Grams	Weight of Oil Diluent, Grams
0.001 to 0.07	5.0 ± 0.01	0.0
0.07 to 0.35	1.0 ± 0.005	4.0 ± 0.5
0.35 to 1.0	0.3 ± 0.002	4.5 ± 0.5
1.0 to 10.0	0.03 ± 0.0001	5.0 ± 0.5

Add 0.5 g. of sodium peroxide and 0.5 g. of zinc oxide, stir with a glass rod, wipe adhering oil from rod with filter paper and add paper to contents of crucible. Heat on an electric hot plate to approximately 100° C. as indicated by a thermometer inserted in a second crucible containing about 5 g. of oil diluent. Heat 30 minutes at 90 to 110° C. Turn off the hot plate, and after 5 minutes add 1 ml. of benzene. Ignite and allow the mixture to burn until all oil has been removed. If the mixture does not burn to completion and an oily residue remains, turn on the hot plate and reignite the oil with a gas burner. Heat over a blast burner until the greater portion of the carbon has been oxidized and until the mass just begins to melt; do not allow the mass to fuse completely or attempt to obtain a carbon-free residue.

Cool the crucible and wash as much of the contents as possible into a 250-ml. beaker, using about 125 to 150 ml. of water in transferring. Add 5 ml. of 8 N nitric acid to the crucible and, after active effervescence ceases, transfer to the beaker. Wash the crucible with about 5 ml. of water from a wash bottle. Repeat the addition of acid, transferring and washing until a total of 20 ml. of acid has been used. Avoid the excessive crucible corrosion which will result from prolonged contact with the acid. Filter the solution through a Whatman No. 40 filter paper into a 500-ml., wide-mouthed, glass-stoppered flask. Heat the filtrate to boiling and treat dropwise with the potassium permanganate solution until it retains the permanganate color. Destroy the excess potassium permanganate by addition of 3 percent hydrogen peroxide, and neutralize to methyl red with ammonium hydroxide solution. Add sufficient solid ammonium nitrate to make a total of 20 g. of ammonium nitrate (including that from the nitric acid and ammonium hydroxide already added; 1 ml. of concentrated ammonium hydroxide neutralized with nitric acid is equivalent to 1.2 g. of ammonium nitrate). Add 5 ml. of 16 N nitric acid.

Heat the solution to 37 to 45° C. and add 30 ml. of freshly prepared ammonium molybdate reagent. Shake vigorously for 2 to 3 minutes, allow the precipitate to settle for 15 to 60 minutes, and filter through an asbestos pad in a Gooch crucible. Wash with small portions of 1 percent potassium

nitrate solution until the precipitate is neutral as determined by a litmus-paper test of the washings. Place the Gooch crucible with the precipitate in the same flask as used above and add from a buret an accurately measured volume of standard sodium hydroxide solution sufficient to dissolve the precipitate, avoiding an excess of more than 3 ml. Add sufficient distilled water to make a total volume of 25 to 30 ml. and shake to dissolve all remaining particles of precipitate. Dilute to 150 ml. with distilled water and add 2 drops of phenolphthalein. Add standard acid until the red color of the indicator is discharged and back titrate with standard sodium hydroxide solution to the first permanent faint pink color.

Determine a reagent blank by repeating the entire procedure but eliminating the sample.

Calculation

Calculate the phosphorus content of the original sample by means of the following equation:

$$\text{Percent Phosphorus} = \frac{[(SN - sn) - (BN - bn)]\,(0.135)}{W}$$

where:

S = volume of sodium hydroxide solution used in sample determination (milliliters),
N = normality of the sodium hydroxide solution,
s = volume of standard nitric or sulfuric acid used in sample determination,
n = normality of the acid solution,
B = volume of sodium hydroxide solution used in blank determination,
b = volume of standard acid used in blank determination, and
W = weight of sample in grams.

Experimental

In the development of the above procedure, an investigation was made of the factors influencing the quantitative precipitation of phosphorus as ammonium molybdiphosphate and the subsequent alkalimetric titration. The preliminary work was done using the general procedure of Hillebrand and Lundell[5] for the alkalimetric analysis of phosphorus, modified as follows:

Obtain 100 to 200 ml. of phosphate solution in a 500-ml., glass-stoppered, Erlenmeyer flask containing 20 grams of ammonium nitrate and 5 ml. of concentrated nitric acid. Heat the solution to 40° C., add 60 ml. of ammonium molybdate solution, stopper, and shake vigorously for a few minutes. Allow the precipitate to settle for several hours and filter through an asbestos pad in a Gooch crucible. Wash with small portions of 1 percent potassium nitrate solution until the washings are neutral to litmus paper. Transfer the crucible plus precipitate into the Erlenmeyer flask and add distilled water. Add sufficient 0.1 N sodium hydroxide to dissolve the precipitate and make the solution basic to phenolphthalein. Add a small excess of standard acid and back titrate with 0.1 N sodium hydroxide to the first permanent pink. Determine the blank on the reagents by repeating the entire proceduce but omitting the sample. (Prepare the molybdate reagent as follows: Dissolve 100 grams of ammonium molybdate in 80 ml. of concentrated ammonium hydroxide, then add 400 ml. of concentrated nitric acid and 600 ml. of distilled water.)

A series of known phosphate solutions was analyzed by the procedure just given, digesting the precipitates two to three hours before filtering. Erratic and generally high values were obtained and the blank determinations gave inconsistent results. Further experimentation showed that the blank titration was dependent on the volume of the distilled water used, becoming reproducible when the final solution titrated was adjusted to a definite volume. Additional analysis of known phosphate solutions by this procedure, however, continued to give slightly high values. To check the influence of time of digestion of the precipitate prior to filtration, a series of known solutions was analyzed and the precipitates allowed to settle from 15 to 60 minutes before filtering. The results of these experiments (Table 1) indicate that, under the given conditions of precipitation, satisfactory results were obtained when the precipitate was digested from 15 to 60 minutes.

TABLE 1

Effect of Time of Digestion Upon Recovery of Phosphorus from Known Phosphate Solutions

Time of Digestion, min.	Phosphorus Present, mg.	Phosphorus Found, mg.	Difference, mg.
15	0.05	0.04	0.01
15	1.20	1.20	0.00
15	2.50	2.46	0.04
15	2.50	2.53	0.03
20	0.10	0.09	0.01
20	5.00	5.02	0.02
30	2.50	2.52	0.02
45	1.20	1.20	0.00
60	0.05	0.03	0.02
60	0.10	0.10	0.00
60	0.10	0.10	0.00
60	0.10	0.10	0.00
60	1.20	1.22	0.02
60	2.50	2.53	0.03
60	5.00	5.06	0.06
60	5.00	5.06	0.06
60	5.00	5.08	0.08

During the course of these experiments the following technical details were established. (1) As expected, it was found that if the ammonium molybdate solution was prepared to the prescribed acidity, within a few days molybdic acid would precipitate out, necessitating a filtration prior to use. This filtration was eliminated by preparing the molybdate reagent as given in the final procedure whereby the nitric acid is not added until just before the reagent is used. (2) It was also established that large quantities of precipitate were difficult to wash free of nitric acid and that repeated washings caused low results, possibly because of the slight solubility of the precipitate. (3) Furthermore, large amounts of precipitate, and consequently large titrations, gave indefinite end points because of the development of a molybdenum blue color when phenolphthalein was used as the indicator. Reliable results were obtained when the amount of phosphorus in any one solution was between 0.05 and 5.0 mg. (4) Although initial experiments were conducted using 60 ml. of the ammonium molybdate reagent, the subsequent work showed that 30 ml. was sufficient to give complete precipitation for 5 mg. or less of phosphorus.

The composition of the yellow precipitate is assumed to be ammonium molybdiphosphate

$$(NH_4)_3\,[P(Mo_3O_{10})_4]$$

as commonly accepted in modern textbooks on inorganic chemistry. This precipitate behaves as an acid and is thought to react with sodium hydroxide in a manner requiring 23 moles of base for one gram-atom of phosphorus. On this basis, 1.0 ml. of 0.1 N sodium hydroxide is theoretically equivalent to 0.135 mg. of phosphorus. Since the titration was found to be accurate to 0.1 ml. of sodium hydroxide, it is possible to determine 0.05 ± 0.01 mg. of phosphorus; this is in accordance with our experience. Also, experience indicates that as little as 0.005 mg. of phosphorus can be definitely detected even though this amount was too small to be established definitely by titration with 0.1 N sodium hydroxide solution.

To establish the applicability of the precipitation procedure to the analysis of the inorganic residue obtained on ignition of a lubricating oil, tests were made to determine the interfering effect of other possible elements in the final analysis for phosphorus. A series of solutions containing 2.50 mg. of phosphorus, 0.5 gram of sodium peroxide, 0.5 gram of zinc oxide, approximately 0.15 gram each of lead, calcium, barium, magnesium, copper, sulfur, and chlorine, and approximately 0.015 gram of iron were analyzed by the recommended procedure. The greatest deviation from the true phosphorus content was

found to be 0.01 mg., indicating that these elements caused no interference.

Very little difficulty was encountered in the decomposition of lubricating oils by ignition in the presence of zinc oxide and sodium peroxide,[11] although it was found that a nickel crucible was better than an iron crucible because of the greater resistance of nickel to attack by peroxide, acid, and air. An organic phosphate of known phosphorus content was blended with a neutral oil to give a mixture containing 0.10 percent of phosphorus; when this mixture was analyzed by the final procedure, values of 0.0989 and 0.0984 percent were obtained. Using this material as a base stock, further blends were made with a phosphorus-free oil. Analysis of these blends showed a maximum deviation from the true phosphorus value of 18 percent for those samples containing 0.001 percent phosphorus and of 2 percent for those samples containing 0.01 to 0.1 percent of phosphorus.

Table 2 gives the results of analyses of new and used lubricating oils by several cooperating laboratories of ASTM Committee D-2, Subcommittee XI, using the final recommended procedure. Table 3 gives the results of analyses of various organic compounds and indicates the precision of the method for general phosphorus analysis. Table 4 shows the results obtained on a number of commercial phosphorus additives. Table 5 compares the results obtained by the recommended procedure and by the usual Carius method when analyzing organic phosphorus compounds in which the phosphorus is present in various states of oxidation. These results indicate that the procedure gives low results when applied to organic compounds containing reduced forms of phosphorus. However, these compounds are seldom encountered in commercial lubricating oils or additives. In the analysis of these reduced phosphorus compounds it was found that the results varied with the size of sample ignited; generally, the values obtained became higher as the size of the sample ignited was decreased. For example, when 0.2 gram of triphenylphosphine was mixed with 5 grams of neutral oil and analyzed, the results obtained showed a phosphorus content of 5.0 and 5.6 percent, whereas 0.02 gram of sample treated in the same manner gave values of 7.1 and 7.2 percent phosphorus. The Carius values for this same material were 11.58 and 11.64 percent phosphorus.

Little corrosion of the nickel crucible occurs if dilute acid is used and if it is allowed to remain in the crucible for only a short time. If these precautions

TABLE 2
Summary of Cooperative Determinations of Phosphorus Content of Lubricating Oil Samples

Sample*	Cooperating Laboratory	Phosphorus Content, Percent W.		Deviation from Mean		Metals Present[3]
		Present	Found	Repeatability[1]	Reproducibility[2]	
S-1	Shell Development Company	0.001	0.001, 0.001	0.000	0.001	Ba
	Laboratory No. 1		0.002, 0.001	0.0005	0.001	
S-2	Shell Development Company	0.090	0.093, 0.094	0.0005	0.0012	Pb, Ca, Zn
	Laboratory No. 2		0.090, 0.089, 0.090	0.0003	0.0026	
	Laboratory No. 1		0.095, 0.091	0.002	0.0007	
	Laboratory No. 3		0.093	....	0.0007	
S-3	Shell Development Company	0.150	0.148, 0.148	0.000	0.003	Pb, Ba
	Laboratory No. 1		0.16, 0.15	0.005	0.004	
S-4	Shell Development Company	Unknown	0.034, 0.036	0.001	0.001	Ba, Ca
	Laboratory No. 2		0.032, 0.033, 0.033	0.003	0.003	
	Laboratory No. 1		0.043	....	0.007	
	Laboratory No. 3		0.033	....	0.003	
S-5	Shell Development Company	0.070	0.071, 0.072	0.0005	0.007	Pb, Ba, Ca
	Laboratory No. 1		0.09, 0.08	0.005	0.007	Zn
S-6	Shell Development Company	0.070	0.069, 0.069	0.000	0.001	None
	Laboratory No. 2		0.067, 0.067, 0.069	0.001	0.000	
	Laboratory No. 1		0.070	....	0.002	
	Laboratory No. 3		0.065	....	0.003	
S-7	Shell Development Company	0.201	0.202, 0.208	0.003	....	Pb, Ba, Fe
S-8	Shell Development Company	0.099	0.095, 0.100	0.002	....	Pb, Ba, Fe, Ca, Al, Cu
S-9	Shell Development Company	0.667	0.66, 0.65	0.005	....	Pb, Ba, Fe, Sn, Zn, Ca, Si, Al, Mg, Na, H
S-20	Shell Development Company	0.199	0.197, 0.202	0.002	0.002	Pb, Ba, Fe, Ca, Zn
	Laboratory No. 4		0.19, 0.20	0.005	0.003	
	Laboratory No. 5		0.194, 0.201	0.003	0.000	
S-21	Shell Development Company	0.117	0.115, 0.119	0.002	0.003	Pb, Ba, Fe, Ca, Zn
	Laboratory No. 4		0.12, 0.12	0.00	0.006	
	Laboratory No. 5		0.095, 0.118	0.011	0.008	
	Laboratory No. 2		0.113, 0.113, 0.111	0.001	0.002	
S-22	Shell Development Company	0.42	0.418, 0.422	0.002	0.011	Pb, Ba, Fe, Ca
	Laboratory No. 4		0.44, 0.44	0.00	0.009	Zn, Mg, Sn, Cd, Al
	Laboratory No. 5		0.432, 0.433	0.0005	0.001	K, Na, Si
S-23	Shell Development Company	0.407	0.396, 0.396	0.000	0.001	Pb, Ba, Fe, Cd
	Shell Development Company		0.398, 0.404	0.003	0.004	Ca, Zn, Mg, Sn
	Laboratory No. 4		0.39, 0.41	0.01	0.003	Si, Al, Na
	Laboratory No. 5		0.392, 0.391	0.0005	0.006	

[1] Repeatability: Deviation of results in a given laboratory from the mean of the values obtained in that laboratory.
[2] Reproducibility: Deviation of mean result from the over-all mean values.
[3] More than 0.01 percent.
* Based on the data published in table 4 of the 1944 Report of ASTM Committee D-2.

TABLE 3
Results of Analysis of Various Organic Phosphorus-Containing Materials

MATERIAL	Phosphorus Found, Percent
Tricresyl Phosphate	8.4, 8.4
Tribenzyl Phosphate	7.9, 8.1
Trixylyl Phosphate	7.7, 7.8
Contained Trioctadecyl Phosphate	4.1, 4.1
P_2S_8 Organic Product	0.70, 0.71
Commercial Lubricating Oil	0.047, 0.048
Lecithin	3.30, 3.35
Dicetyl Hydrogen Phosphate	5.6, 5.6
Oleyl Phosphate	8.1, 8.1
Monocetyl Dihydrogen Phosphate	8.8, 8.9
Organic Phosphate	0.0989, 0.0984
Diesel Oil	0.001, 0.001
Tri (trimethyl-cyclohexylcarbinyl) Phosphate	6.1, 6.2, 6.2, 6.3
Organic Phosphate	9.4, 9.4
Lubricating Oil	0.039, 0.041
Palm Oil	0.0006, 0.0004

TABLE 4
Results of Analysis of Various Lubricating Oil Additives and Lubricants

MATERIAL	Phosphorus Found, Percent
Extreme Pressure Lubricant	0.002, 0.003
Used Extreme Pressure Lubricant	0.001, 0.002
Used Gear Lubricant	0.001, 0.001
Tributyl Phosphite	10.6, 10.6, 11.2
Lecithin	2.33, 2.33
Lube Oil Additive	1.04, 1.01
Lube Oil Additive	0.036, 0.034
Lube Oil Detergent and Inhibitor Additive	3.7, 3.8
Noncorrosive Detergent Diesel Concentrate Containing a Zn-P-S Inhibitor	1.01, 0.98
Lube Oil Detergent and Inhibitor Additive	1.23, 1.23
Lube Oil Detergent and Inhibitor Additive	1.61
Lube Oil Detergent and Inhibitor Additive	3.12
Lube Oil Detergent Additive	0.48, 0.48
Lube Oil Inhibitor Additive	4.61, 4.63

TABLE 5

Results of Analysis of Organic Compounds Containing Phosphorus in Various States of Oxidation

COMPOUND	Percent Phosphorus Found by a Carius-Gravimetric Analysis	Percent Phosphorus Found by Recommended Procedure of Annalysis
Tricresyl Phosphate	8.44, 8.46	8.40, 8.44
Diestyl Hydrogen Phosphate	5.66, 5.52	5.63, 5.64
Tributyl Phosphite	12.71, 12.84	10.7, 10.7
Dibutyl Phenyl Phosphonate	10.98, 11.13	8.4, 9.2
Triphenylphosphine	11.58, 11.64	7.1, 7.2

are observed, it has been possible to use the same crucible for several dozen determinations. The crucible life is also extended by proper ignition of the ash remaining after burning off the oil. It is not necessary, and furthermore it is undesirable, to ignite the residue until all carbon is removed. Experience has shown that the ignition should be carried only to the point where the residue begins to melt, not until fusion takes place.

The recommended method has been satisfactorily applied to the analysis of approximately 200 samples of lubricating oil and to a large number of other materials containing 0.001 to 0.3 percent phosphorus.

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TOXICITY OF HYDROGEN SULPHIDE TO MEN

(National Safety Council)

H_2S Percent	0-2 Minutes	2-15 Minutes	15-30 Minutes	30 Min.—1 Hour	1-4 Hours	4-8 Hours	8-48 Hours
0.005 0.010				Mild conjunctivitis; respiratory tract irritation.			
0.010 .015		Coughing; irritation of eyes; loss of sense of smell.	Disturbed respiration; pain in eyes; sleeplessness.	Throat irritation.	Salivation and mucous discharge; sharp pain in eyes; coughing.	Increased symptons*.	Hemorrhage and death.
0.015 .020		Loss of sense of smell.	Throat and eye irritation.	Throat and eye irritation.	Difficult breathing; blurred vision; light shy.	Serious irritating effects.	Hemorrhage and death.
0.025 .035		Irritation of eyes; loss of sense of smell.	Irritation of eyes.	Painful secretion of tears; weariness.	Light shy; nasal catarrh; pain in eyes; difficult breathing; conjunctivitis.	Hemorrhage and death.	
0.035 .045		Irritation of eyes;* loss of sense of smell.	Difficult respiration; coughing irritation of eyes.	Increased irritation of eyes and nasal tract; dull pain in head; weariness; light shy.	Dizziness; weakness; increased irritation; death.	Death.	
0.050 .060	Coughing; collapse and unconsciousness*.	Respiratory distrubances; irritation of eyes; collapse*.	Serious eye irritation; light shy; palpitation of heart; a few cases of death.	Severe pain in eyes and head; dizziness; trembling of extremities; great weakness and death.			
0.060 .070 .080 .10 .15	Collapse;* unconsciousness;* death.	Collapse;* unconsciousness;* death.					

*Data secured from experiments on dogs which have a susceptibility similar to men.

Calculation of Orifice Meter Coefficients for Natural Gas

GEORGE H. FORSTER, JR., The Texas Company

PAPER No. 1 of the Southern California Meter Association's Meter Course covered (a) Fundamental Gas Laws and Their Application to Orifice Metering; (b) Fundamentals of Orifice Meter Measurement. The basic gas laws pertaining to orifice meter measurement and the necessity of applying correction factors for each and every gas being measured were given. The correction factors are necessary of course, to express the quantity of natural gas being measured through an orifice meter in terms of standard cubic feet, defined as follows: A standard cubic foot of gas is that quantity of gas which, at a temperature of 60°F. and an absolute pressure of 14.73 pounds per square inch, occupies one cubic foot.

All of our present tables and equations used in California, give results in this unit.

As this paper is dealing with coefficients, the definition of a coefficient as it pertains to orifice-meter measurement follows: The coefficient is a part of the orifice-meter formula that may, when the data of the meter set-up is known, be condensed into a single numerical quantity and, in this simple form, be used repeatedly, so long as the data of which it is composed, is unchanged, and, is the amount of gas in standard cubic feet, which will pass through an orifice in one hour at one pound absolute pressure and at one inch water differential.

This equation is written

$$Q = C' \sqrt{h P_2}$$

Where C' = Coef. corrected
h = differential in inches of water
P_2 = absolute pressure (downstream of orifice plate)

We are indeed fortunate that the ground work has been done, tables prepared and even further simplified to the extent that coefficient calculations are a very simple procedure.

The Basic Standard Natural Gas Hourly Coefficients (C), both Flange Connections and Pipe Connections are published for Standard sized orifices in Standard sized tubes. The basic coefficients are at a pressure base of 14.73 pounds per square inch; an absolute temperature of 520°F. and a specific gravity value of 1.00 (air). Beside standardizing on these factors, two more assumptions had to be made. One is that the value of $\sqrt{hP_2}$ is infinite, i.e., the Reynolds number is infinite, and the other that $\frac{h}{P_2}$ is zero, i.e., no expansion throughout the flow range. Of course, corrections for these two conditions are made on actual flow conditions.

For odd-sized orifices or old-sized tubes, compute (C), from the equation $C = d^2 ZL$.

Tables for Z and L are given for both Flange and Pipe Connections.

Computation of C'—corrected coefficient for flowing conditions.

$$C' = C \times F_G \times F_T \times F_{PV} \times F_{e2} \times F_R$$

C = Basic coefficient (just discussed)

F_G = Specific Gravity Factor $\sqrt{\frac{1.000}{G}}$

F_T = Flow Temperature Factor $\sqrt{\frac{460+60}{460+\text{observed Temp.}}}$

F_{PV} = Superexpansibility Factor $\sqrt{Y}$

C.N.G.A. Bulletin TS-354 gives factors for this correction, based on experimental data, and it is a function of specific gravity, temperature and absolute pressure; for deviation from Boyle's Law and Charles' Law.

F_{e2} = Expansion Factor (From Tables)

This factor depends on the value of beta, that is, the ratio of orifice diameter to actual internal pipe diameter $\frac{d}{D}$, and on the ratio of the differential pressure to the static presure, $\frac{h}{P_2}$.

F_R = Reynolds Number Factor $1+\frac{S}{\sqrt{h P_2}}$

(S remains constant for any given orifice and pipe size)

The Reynolds factor varies with beta, pipe diameter and the Reynolds number. The Reynolds number varies with the velocity—orifice diameter—density and viscosity, with density and viscosity assumed to be constant.

Both the F_{e2} and F_R Factors differ for Pipe and Flange Connections requiring tables for each type of connection.

For Tables—Nomenclature—and constants used in Tables, refer to C.N.G.A. Bulletin TS-353 and/or S.C.M.A. Data Sheets 193 to 208, inc. Also C.N.G.A. Bulletin TS-354 for Superexpansibility Factors

One additional factor shall be applied to the equation for correcting for C' and that is, the factor for Meter Differential Range and Spring Range when square-root charts are used. This factor has the symbol M and follows C in the sequence.

$$M = .01\sqrt{R_h R_p}$$

Sample Procedure—Regular Charts

Given Conditions

Flange Connections — 50# Spring 50" Meter
6" line (6.025) — 2.75" orifice
Specific Gravity .915 — Flow Temperature 85° F.
Differential Pressure 33". Static Pressure (P_s) 18# ga.

(C.N,G.A. Bulletin TS-353)
C from Table 1 = 1571.8
F_G from Table 13 = 1.0454
F_T from Table 14 = .9768
F_{PV} from C.N.G.A. Bulletin TS-354 = 1.0029
Table A-5 factor for .915 S.G. — 85° F. — 100# abs. = 1.0163
18# ga. + 14.73 = 32.73# abs. Factor sub Table F' = .1791
.0163 × .1791 = .0029 + 1 = 1.0029
F_{tf} from Table 6 = 1.0063

$$\text{Beta} = \frac{2.75}{6.025} = .45$$

$$\frac{h}{P_2} = \frac{33''}{18 + 14.73} = \frac{33}{32.73} = 1.0$$

F_R from Table 4 = 1.0009
S(6.065 by 2.75) = .030

$$\sqrt{h\,P_2} = \sqrt{33 \times (18 + 14.73)} = 32.86$$

$$1 + \frac{S}{\sqrt{h\,P_2}} = 1 + \frac{.030}{32.86} = 1.009$$

C' = 1571.8 × 1.0454 × .9768 × 1.0029 × 1.0063 × 1.0009
= 1621.4 hourly coefficient

$$Q = C'\sqrt{h\,P_2}$$

$$= 1621.4 \times \sqrt{33\,(18 + 14.73)}$$

= 1621.4 × 32.86
= 53 MCF per hour

Sample Procedure—Square Root Charts

Given Conditions

Same as for Regular Charts except that chart readings will be in square root of 33" diff. and of 18# ga. + 14.73 abs., or 8.12 diff. and 8.09 static for 50# 50" meter.

C from Table 1 = 1571.8
M from Table 16 = .5000
F_G from Table 13 = 1.0454
F_T from Table 14 = .9768
F_{PV} from C.N.G.A. Bulletin TS-354 = 1.0029
Table A-5 factor for .915 S.G. — 85° F. — 100# abs. = 1.0163
Static 8.09² × .5000 = 32.73# abs.
Factor Sub Table F' = .1791
.0163 × .1791 = .0029 + 1 = 1.0029
F_{tf} from Table 6 = 1.0063

$$\text{Beta} = \frac{2.75}{6.075} = .45$$

$$\frac{hs}{P_{s2}} = \frac{8.12}{8.09} = 1.0 \text{ refer to Table 15}$$

$1.0\ \frac{h}{p}$ for 50# 50" meter = 1.0 for use in Table 6

F_R from Table 4 = 1.0009
S(6.065 × 2.75) = .030
$Mh_s\ P_{s2}$ = .5000 × 8.12 × 8.09 = 32.84

$$1 + \frac{s}{Mh_s\ P_{s2}} = 1 + \frac{.030}{32.84} = 1.0009$$

C'M = 1571.8 × .5000 × 1.0454 × .9768 × 1.0029 ×
1.0063 × 1.0009 = 810.6 hourly sq. rt. coef.

$Q = C'Mh_s\ P_{s2}$
= 810.6 × 8.12 × 8.09
= 810.6 × 65.69
= 53 MCF per hour.

One can see from the detail work necessary, that many coefficient calculations, although fairly simple, can be very tedious. The C.N.G.A., The Pacific Coast Gas Association and The Southern California Meter Association, through a joint committee went to work to simplify the coefficient calculation procedure.

In 1941, the work of this committee appeared as C.N.G.A. Bulletin TS-402 and quoting from the preface "The method presented involves no basic change from the original data, but affects only that part of the procedure pertaining to the application of the correction factors. Simplicity in the application of these correction factors has been accomplished by

"1. Establishing a new sequence for the application of the correction factors, setting the most variable factors at the end of the computation sequence.

"2. Combining the original Reynolds and Expansion factor correction tables into a single table requiring only one reference.

"3. Introducing a combination temperature and specific gravity table.

"4. Including a simplified tabulation of the super-expansibility tables developed in C.N.G.A. Bulletin TS-354 to eliminate the necessity of an outside reference for this correction factor."

This manual is a work manual, while C.N.G.A. Bulletin TS-353 still remains as the basic textbook for coefficient calculations here on the Pacific Coast.

We shall now calculate a coefficient, the simplified way, using the same given conditions as before.

Regular Charts

Coefficient Record									Type Connection
h	$\frac{h}{P_2}$	Ext. Group	Line and Orifice	Meter Range		Gauge Press.	Gravity	Temp.	
Pres. lb. ga.	Beta	S Group	C		$F_{e2}F_R$	F_{PV}	F_G	F_T	C'
Given Conditions							Flange		
33.0			6x2.750	50 lb 50"		18.0	.915	85	
18.0									
Found									
	1.0	7							
	.45	(1)	1571.8		1.0007	1.003	1.022		1622.4

Table 1 50# Spring 50" gauge

$\frac{h}{P_2}$ = 1.0 Ext. group = 7

Table 2 F Beta = .45-S group = 1 — C = 1571.8

Table 3 F F_{e2} F_R = B (.45) to $\frac{h}{P_2}$ (1.0)
down to Ext. group (7) at S group (1) = 1.007

Table 4 F_{PV} @ 60° F. = .910 @ 15# = 1.004
Table 4 T-F_{PV} @ 85° F. = 1.004 @ 60 to 1.003 @ 85° F.
Table 4 Sp. Gr. & Temp. Factor .915 @ 84° F. = 1.022
C' = C × F_{e2} F_R × F_{PV} × F_G F_T
= 1571.8 × 1.007 × 1.003 × 1.022 = 1622.4

$$Q = C' \times \sqrt{33 \times (18 + 14.73)}$$

= 1622.4 × 32.86
= 53 MCF per hour.

Square Root Charts

Coefficient Record									Type Connection
h_s	$\frac{h}{P_2}$	Ext. Group	Line and Orifice	Meter Range		Gauge Press.	Gravity	Temp.	
P_{s2}	Beta	S Group	C	M	$F_{e2}F_R$	F_{PV}	F_G	F_T	C'
Given Conditions							Flange		
8.12			6x2.750	50 lb. 50"			.915	85	
8.09									
Found									
	1.0	7				15.0			
	.45	(1)	1571.8	.5000	1.007	1.003	1.022		811.3

Table 1 50# Spring 50" gauge

$\frac{h_s}{P_{s2}}$ = 1.0-Ext. Group = 7 — M = .5000 — Ga. Press. = 15#

Balance same as for Regular Charts
C' = C × M × F_{e2} F_R × F_{PV} × F_G F_T
1571.8 × .5000 × 1.007 × 1.003 × 1.022 = 811.3
$Q = C' \times h_s \times P_{s2}$
= 811.3 × 8.12 × 8.09
= 811.3 × 65.69
= 53 MCF per/hr.

Advances in the Use of Laboratory Fractionating Columns

VON DR. F. HILBERATH

Translated from Oel u. Kohle by E. J. Barth, Petroleum Technologist

ACCURATE laboratory techniques and the use of appropriate distillation and fractionating apparatus have, despite the war, become more imperative and more demanding, both in the field of analytical and preparational organic chemistry.

In the field of petroleum research new procedures in the use of rectification apparatus for laboratory use have become of special significance not only in preparing organic products on laboratory scale, but also in the analyses of materials from alkylation processes, the cracking industry, isomerization processes, and the like; here new trends have been of great value also in quick analytical determinations.

Again the use of newly developed columns has enabled the organic chemist actually to isolate many types of definite hydrocarbons from raw materials and from crude products that otherwise would have been of less commercial value. New methods of fractionation have become the very basis of the modern synthetic petro-chemical industry which is built around the aliphatic chemistry of petroleum hydrocarbons.

It is apparent, however, that many new types of apparatus and highly efficient laboratory columns are not as widely used as one would be led to believe from a reading of the recent literature on this subject. For instance, in the many laboratories of our technical schools as well as those in many of the oil refineries there are still antiquated procedures being used and very often quite the improper type of column employed for a certain specific job. This situation exists today despite the fact that a long list of distillation specialists have in the last 10 years developed and perfected a well nigh endless number of fractionating columns, vacuum flasks, stills, reflux columns, and the like. The reason for this, for example, may well be in the fact that the arbitrary use of this or that type of apparatus has been more or less definitely described in organic textbooks for certain specific preparations or certain liquids which are to be distilled, rather than a true basic knowledge of distillation phenomena themselves. The latter should really underlie any good judgment in the selection of a column which is efficient throughout many ranges of distillation.

Today many of the newly developed fractionating apparatus have been well described as to their definite physical advantages and they do, in general, present no special obstacles to their use even though many of the very latest highly efficient columns may not all contain labor-saving devices or such fool-proof additions as electrically-controlled reflux-valves, and the like. Many columns can be slightly modified in the laboratory for certain specific jobs but to do this is not always according to true principles, both physical and chemical; and changes hastily made in the laboratory usually are not accurate. Secondly, the average chemist also will find it very tedious to seek in the foreign literature the description and dimensions of some specific column which he has in mind for immediate use.

Rules Concerning Laboratory Fractionation

It is not possible to detail here the complete theory of fractional distillation but we wish in the following paragraphs to point out a few of the fundamental postulates connected with distillation which underlie procedures for carrying out efficient separations of liquids according to their boiling points.

When one considers the construction and use of the old type of Hempel column and the more recently evolved Widmer column it should be well borne in mind that the advances in the efficiency in these columns during recent years were really initiated when large-scale plant towers and fractionating columns used in refineries were first built to yield the ultimate in close-cut plant fractionation. It then became necessary for many a plant chemist to find some column, usually made of glass, that could be used in the laboratory which he then hoped would give him the same amount of light cuts which the plant superintendent commercially obtained through a plant column which was correctly designed and constructed.

The first advances in the improvement of columns was made in 1923 by E. Jantzen who developed fractionation techniques some five years before improvements had been made in American plant practice. In a lecture before The Chemical Society he pointed out at that time three fundamental conditions which remain to this day necessary for good fractionation. They are:

1. The greatest concentration for enrichment of a certain cut during the distillation can only be obtained by a countercurrent exchange between vapor and liquid.

2. The process should possibly be conducted in adiabatic manner, that is, withdrawal of heat from the column or cooling or externally heating the column, which in the first case leads to partial condensation; or in the second, to vaporization created on the fractionating plate, both of which are to be avoided.

3. Reproducible fractionation free from all the errors of arbitrary methods of operating is only possible when the column is under steady flow of charging stock with a constant not overburdening charge of oil to be distilled and by closely controlling some definite reflux ratio, which should be held constant for the particular oil and fractions. In this way and with the use of a dephlegmator which aids in obtaining some partial condensation of the vapors at the top of the column, a highly efficient performance of a column can be obtained. The use of this partial condenser gives added contact between reflux and vapor and it does prevent complete condensation of all the vapors at the top of the column. Jantzen built a glass tube spiral column[1] based on the abovementioned principles; this column still finds good application today.

Selecting A Column and Conditions of Operation

If one chooses distillation equipment, which satisfies the above principles there remain, nevertheless, a great many types, shapes, and lengths of columns which can be used for some operation but which merely differ from one another in some special attachment or added "control-unit" which may be an advantage, or which again in other cases, as small differences may become real disadvantages. In the case of columns and their useful efficiency they can be compared and actually evaluated only by the use of recently adapted standards of comparison, or units based on physico-chemical conceptions. For this purpose it suffices in general to understand and become acquainted with four physical principles underlying rectification: namely, the theoretical number of plates as a measure of the fractionation efficiency; "working-hold up," a determinable factor useful in finding the amount of some intermediate cut and is in reality some part of the product which during the operation of the column exists

TABLE 1

Available Theoretical Number of Plates in Relation to Boiling Point Difference for Separating Binary Mixtures of Hydrocarbon at 760 mm.

Temperature Difference (° Centigrade)	Theoretical Plates
1.5	100
3	55
5	30
7	20

in the column partly as reflux and partly as vapor; the capacity, or optimum load, which is a measure of the throughput of the column, and finally, the operating or existing pressure in the column, which is related to the boiling point of the liquid in the still and is very important in vacuum distillation.

A distillation curve can next be calculated and obtained for any definite working condition, according to A. Rose and others[2], if the theoretical number of plates and "working-holdup" for the column are given and if the vapor pressure of the liquid for various temperatures is known; (that is, the quantitative or molal weight curve of the components in the fraction obtained). In this manner one can decide whether the efficiency of the column and the chosen working conditions will give the desired cuts and closeness of fractionation.

After many distillations when using very many types of columns one becomes quite proficient eventually in choosing columns from the previous results obtained. Applying this procedure for instance, to the fractionation of a mixture of equal parts of two hydrocarbons showing an average vapor pressure ratio of a 1.2 (equivalent to a boiling point difference of 5 degrees at normal pressures), it will be seen that a column containing 30 theoretical plates will be necessary for clear-cut separation and which will yield a good practical distillation curve. In the above calculation it is understood that the reflux ratio is being held at 1-30, and that a tenfold "working holdup" exists in the column.[3]

Continuing the calculation one arrives at the figures shown

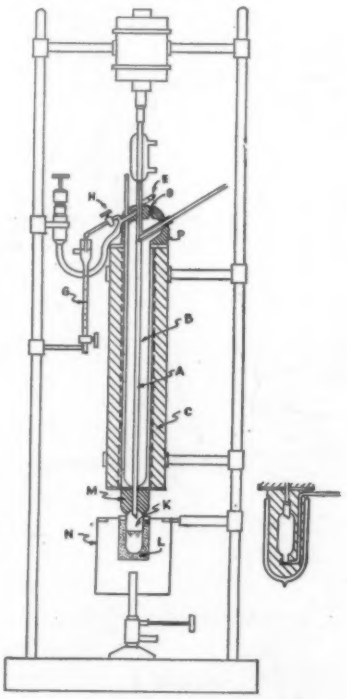

FIGURE 1

Column with rotating metal band, for distilling small quantities of liquid.

in Table 1 showing the least number of plates necessary for distillations at normal pressures in relation to the temperature difference of the components in the mixture.

These calculated figures used in conjunction with the method described above by Rose afford a true method of evaluating working conditions and the proper selection of fractionating columns. The author believes, however, that by the use of more universally established units of comparison petroleum chemists can still further simplify calculations and arrive at improved methods for choosing certain columns which they may prefer. Some of the more abstract units which underlie the theory of distillation should be simplified in order to improve the above methods of calculations[4].

For instance, if one uses the above described distillation as a unit example one could obtain relative efficiencies of various columns by further considering the factors of optimum capacity of the tower, reflux ratio, time of distillation (flow of vapor per unit time), and similar constants which should be known. Assuming that the chemist is willing to overlook

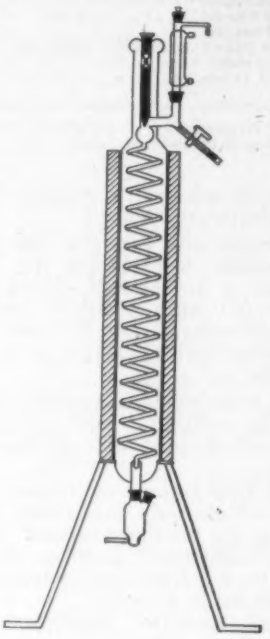

FIGURE 2

Glass tube spiral column, modified. (Jantzen)

the factor of quantity production he will naturally choose for his analytical work a column of the type which will afford the shortest duration of time in which to conduct the distillation. When, however, small amounts of fractions or raw materials are being handled columns should be chosen which will conduct the distillation with the smallest possible amount of "working-holdup" and where the distillation flask is in the proper volume-ratio to the capacity of the column. In preparation work the quantity of distillate obtained per hour per charge should be determined and kept at a maximum without neglecting the sharpness of the cuts obtained. It is therefore of great advantage to determine comparative figures for the most important type of columns and we have tabulated the values obtained for these columns in Table 2.

In Table 2, for instance, the important constants of several columns are shown in the lefthand portion of the tabulation. The data here have been taken partly from the literature and partly from personal investigation. The values are somewhat approximate since the same raw oils and working conditions did not obtain in all cases. Using these figures as a basis the righthand portion of Table 2 indicates comparative values calculated from the known data.

The calculations were then used in further choosing a column and actually conducting a distillation through this column. The various items in Table 2 also give comparative figures for distilling many types of substances and oils under working conditions other than described in this table.

Types of Efficient Fractionating Column

Below we shall describe a series of fractionating apparatus which have become popular and should, in the opinion of the author, be further described.

First in line among columns which have shown excellent efficiency, especially for the distillation of small amounts of material as in analytical work, is an apparatus containing a rotating band of metal fitted vertically in the inside of the

TABLE 2

Comparative Efficiencies of Various Types of Columns

DESCRIPTION	Data From Literature			Comparative values based on 30 theo. plates, stil. capacity or charge equal to 10 times the total "hold-up", and with Reflux-Ratio of 1:30			
	Plate Value (cm^3)	"Working-Hold-Up" (cm^3)	Capacity (cm^3/hr.)	Height of Fractionater (cm)	Rate of Distillate (cm^3/hr.)	Charging Capacity (cm^3)‡	Time of Distillation (Hr.)
Column with packing; 10 mm. dia. (4 mm. Helix-glass spirals, 1 winding[5])	3.9	0.8	240	115	8	240	30
Jantzen spiral column, 7 mm. dia.	4.0†	0.2	60	120	2	60	30
Stedman[6] packing, 3.6 mm. dia.	1.25	0.2	190	37.5	6.5	60	9½
Stedman[6] packing, 19.0 mm. dia.	1.50	0.5	340	45.0	11.5	150	13
Stedman[6] packing, 25.0 mm. dia. (all of wire)	2.0	0.75	500	60.0	16.5	225	13½
Stedman[6] packing, 32 mm. dia.† (glass fritted filling)	3.7	4.0	1000	110	33.0	1200	36
Sieve-plate column[7] Groll (25 mm. dia.)	2.9	1.65	1300	87	43	500	11½
Sieve-plate column[7] Groll, 32 mm. dia.	3.5	3.00	2000	105	73	900	12½
Column with Rotating section (Mair & Willingham[8], 51 mm. dia)	1.0	1.5	420	30	14	465	33
Column with Rotating band of metal, 6 mm. dia.†	2.5	0.02	60	75	1.*	6	6*
Heli-grid Podbielniak column[9], 11 mm. dia.	1.15	0.2	250	34	8.5	60	7

* Reflux-ratio 1:60. † Personal data. ‡ Capacity of "hold-up" was considered; for more accurate calculations, add to the column "hold-up", the "hold-up" of any added "still-head," and vapor=hold-up of the distilling vessel.

column and driven by an electric motor[10]. The apparatus is shown diagrammatically in Figure 1.

This column operates with very low "working-holdup" and gives sharp separation. Considering the whole apparatus quantities of charge as low as 5-25 cc. may be distilled; as low as 2 cc. of material can be distilled if such material boils normally without difficulty. Table 2 shows that this column can be operated under high efficiency at a very high rate of distillate per minute.

The glass spiral tube column according to Jantzen[1] gives very good service for analytical work and for accurate fractionation using medium quantities of liquid charge, such as 50-250 cc.

The load which this column will carry is, nevertheless, small. Much more efficient are the columns containing wire mesh gauze, such as the Stedman column[6], or the Helix-Grid packing used by Podbielniak[9]. Both of these columns are, however, difficult to construct in the laboratory and would probably have to be made to order.

Klein, Stage, and Schultze[11] developed a plate column

FIGURE 3

Three-chambered pipe and plate column. (Klein, Stage and Schultze)

(Figure 3) constructed entirely of glass which will handle quantity charges of about 200 cc. of liquid.

As can be seen from Figure 3 the column will operate at very low "working-holdup," which is usually quite appreciable with bell-shaped plate columns. This low "holdup" in the column is obtained by a special arrangement in the construction of the plates as shown in the diagram.

H. Groll[12] developed an apparatus consisting of a plate column of glass which will handle larger charges of oil (Figure 4).

The efficiency of the plates and the load that this column will carry is extremely good due to the special construction of this column. One is able to distill anywhere from 250-2000 cc. of charge depending upon the selection of the diameter of the column which may be used. If one wishes to distill

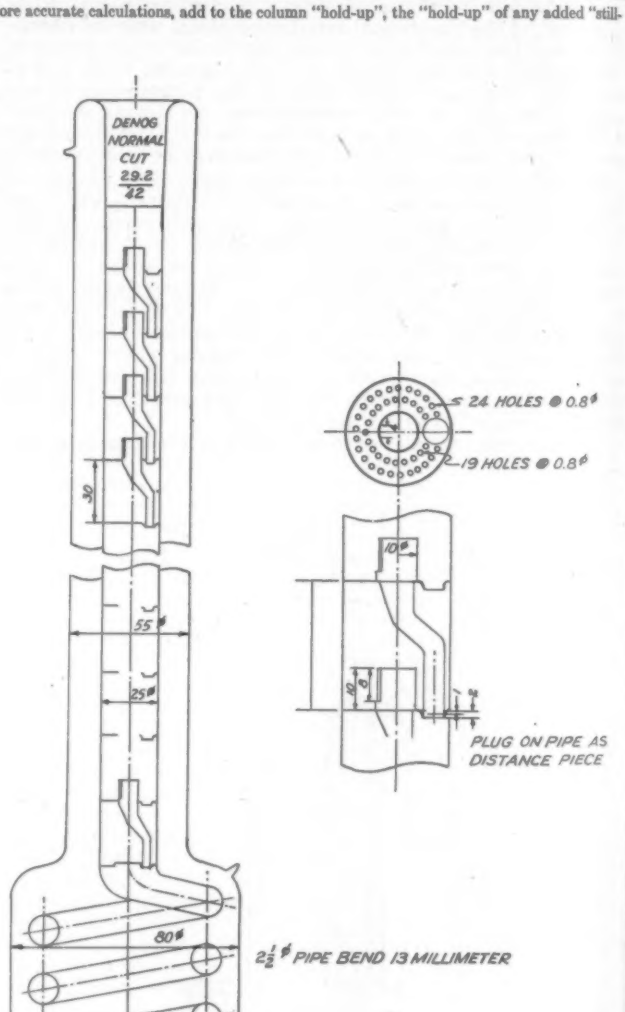

FIGURE 4

Plate column. (Groll)

1-5 litres of charge it is of great advantage to use a tube of about 30 mm. diameter packed with some type of filler or coarse packing, say 3 mm. in diameter. This type of column was described by H. Tramm[13] and is equipped with a pressure regulator as well as an attachment to measure the amount of reflux.

Depending on the working conditions as to what is desired in the way of charging capacity, degree of fractionation, amount of "holdup," etc., one can choose as packing for this column various types of materials; such as Raschig ring,

saddle packing, helices, or as advocated by K. Sigwart,[14] a packing manufactured of iron wire and fashioned into small individual rings is also advantageous.

A further modification of the last mentioned column by that author will be described further below. Where much larger quantities of liquid are to be distilled in the laboratory

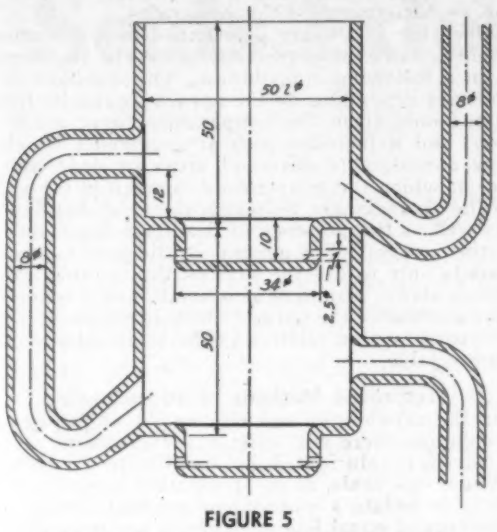

FIGURE 5
Injection spray circulation column. (Sigwart)

a plate column developed by Sigwart[15] at the I. G. Works is shown in Figure 5. This column operates at very high efficiency under all types of high load and rapid distillation conditions. It is constructed entirely out of glass in individual sections of five plates each and can then be built up to various heights by assembling the individual sections. It is an efficient column in all work on continuous distillation where the charge may be injected into the middle portions of the section and a continued distillation conducted. The column is of great value in designing large-scale commercial equipment.

The above types of apparatus so far described are useful only to distill substances boiling above room temperature. Other types of distillation columns used in the industry are those known as low-temperature distillation columns. Three low-temperature arrangements will be described below, the two first of which are of special use for the analyses of gas mixtures.

The column shown in Figure 6 is used in the main laboratories of the I. G. Company.[16] Distillations are conducted at pressures of 30 mm. The temperature of the cold bath at the head of the column which corresponds to the approximate boiling point of the distillate is gradually increased in small increments. The distillate is condensed in receivers under vacuum.

Another procedure for conducting low-temperature fractionation is that of Podbielniak,[17] whose column, as is well known, contains wire or gauze packing. In this arrangement the distillate is sucked as a vapor into evacuated glass flasks. The amount of charge, tightness of packing and the yields of distillate that can be obtained through these columns usually is determined in one of the runs by the increase of pressure during the distillation. The apparatus has been made quite foolproof by minimizing as much as possible the personal errors of the operator, and it also contains an arrangement for the regulation of pressure during the distillation. Figure 7 shows the diagram of a distillation setup containing some of the arrangements previously advocated by H. Groll[12] and H. Tramm.[18]

For the purposes of preparing organic compounds in the research laboratory an apparatus built along the lines of that shown in Figure 8 is especially noteworthy[18]. It contains a reflux or "knockback unit," cooled with water, which completely condenses sufficient liquid so that any desired reflux ratio may be maintained. The distillate may be obtained as liquid reflux or as vapors to be condensed later; these fractions are obtained as close cuts even at high rates of distil-

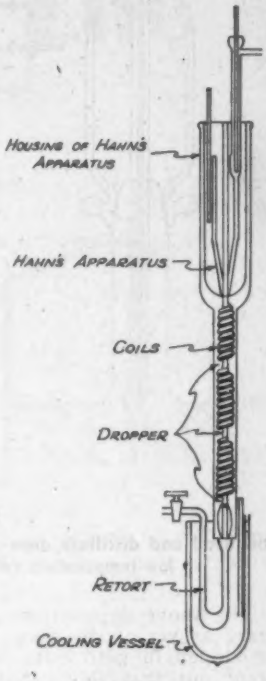

FIGURE 6
Low-temperature column. (I. G. Company)

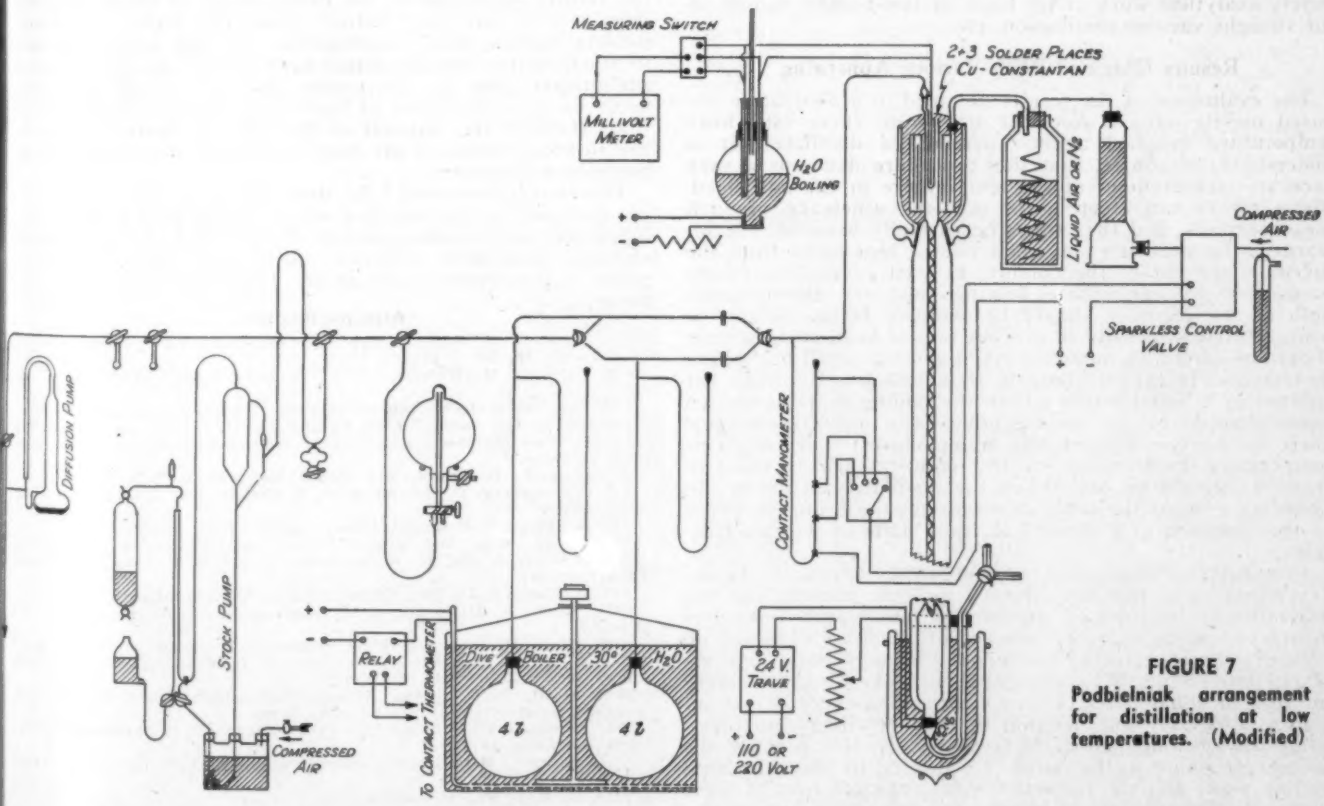

FIGURE 7
Podbielniak arrangement for distillation at low temperatures. (Modified)

lation. This type of a low-temperature column can be operated at any of the above-mentioned ranges of temperature described for previous columns and is serviceable during many days of continuous operation.

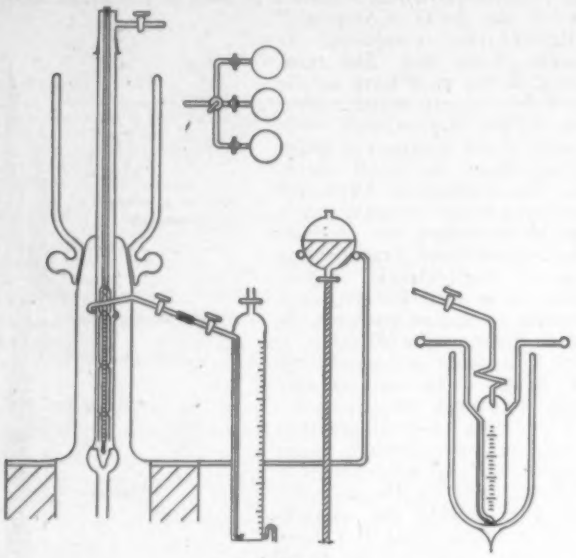

FIGURE 8

Still head and distillate draw-off arrangement for preparative work; a low-temperature column by Kock and Hilberath.

The above descriptions do not constitute a complete summary as yet of the many types of columns that have been developed in petroleum laboratories and the author would point out that those industries which are concerned with distillation problems should combine, discuss and publish in the form of proceedings complete descriptive matter and recommendations as to which of these special columns is particularly useful for some definite purpose, such as for purely analytical work or for high- or low-boiling liquids, or for straight vacuum distillation, etc.

Results Obtained With Various Apparatus

The evaluation of the results obtained in a distillation are based mostly upon a so-called distillation curve (still-head temperature graphed against percent of distillate). It is understood, of course, that this procedure demands a very accurate measurement of the temperature in the still head. Many errors can creep in to mar the efficiency of such measurements, and they must be carefully avoided; for instance, a far reaching and rapid loss of heat away from the thermometer out of the column, as well as cooling effects occasioned by condensate flowing past the thermometer bulb or the recorder should be avoided. If the column is being heated externally to prevent loss of heat, such heating should be carefully controlled and applied in small but steady increments. If the distillate is obtained directly from the column as a liquid fraction then the boiling point is chosen corresponding to the boiling point of a mixture of equal parts of the two components laying closest together. This temperature corresponds to the point at which the two fractions should be cut. When the distillate fraction is obtained as a vapor the temperature to cut the fractions would be the dewpoint of a mixture of equal parts of the two fractions.

Fortunately, temperature measurements appear to be independent as to the method used for this purpose, but the evaluations of curves dependent on temperature measurements plotted against the percent of fractions obtained do present inherent errors. We would like to make a few remarks concerning this statement. When one distills a binary mixture of equal parts of two components there is, for instance, invariably the fact that the lower-boiling component being always obtained of least purity. In this manner the 50 percent point on the curve is displaced by the calculated boiling point and the refractive index, upward toward some higher distillate fraction percent; secondly, the presence of a larger amount of the lower-boiling component in the original raw mixture will be displaced.

A study of the shape of the theoretical distillation curve shows that the magnitude of this deviation or discrepancy is quite dependent on the theoretical number of plates, the relative volatility and concentration of the components in any one of the fractions that may be chosen for study; it is, however, independent of the reflux ratio and "working-holdup." This magnitude is a measurable quantity and can be determined from the equation below for any definite or known concentration of the raw material:

$$\Delta\chi = f(a^n) - K,$$

a = Relative Volatility

n = Theoretical Number of Plates

K = A constant for the Apparatus.

The values for $f(a^n)$ are determined by calculation. We will present a table of correction values in the form of a diagram in a following contribution. The constant K, a so-called constant depending on the apparatus and its form, can be evaluated only from the temperature curve made of the distillation; and it includes such arrangements which carry or possess considerable dead-end areas or dead-end space. The point at which the temperature is taken in the still head and also the arrangement by which the total distillate is obtained, as well as the presence of dead-end space, differ very much in this respect[19]. For general considerations one nevertheless needs only to use the first portion of this correction curve shown above, assuming a^n is small; and to employ only the second portion of the curve (which is negative) when the dead-end space or area relative to the total volume of distillate is appreciable.

Improved Methods of Procedure

Despite the capabilities and efficiencies of the newer laboratory columns there still exist many problems which can not be solved or elucidated by distillation or rectification alone. Where one deals, as in preparation work for instance, and desires to isolate a material or product from a mixture of components of equal boiling point, it becomes worthwhile and necessary to make use of added liquids or employ so-called "azeotropic mixtures." The literature is quite replete with many lists of various liquids useful for separating various hydrocarbon types. Such liquids are, for instance, methyl alcohol, acetic acid, methyl cyanide, and several glycol monoalkyl ethers[19].

For analytical purposes optical procedures such as Raman analyses[20] afford excellent analytical tools. In this category the use of analysis made by ultrared and ultraviolet light is becoming increasingly important.[21,22] These optical methods furnish accurate results and are exceedingly promising for the future. Nevertheless, the development of these methods does not in any way detract from the highly improved modern techniques of fractionation. In fact modern means of fractionation are absolutely necessary in most cases as a preliminary step in the proper use of optical analytical methods. A combination of both these working principles or tools stand at the disposal of the research worker today in the future solution of the many problems still remaining in petroleum chemistry.

The above-mentioned brief descriptions of aids and working methods for fractionation which can be used today in the laboratory and which stand at the disposal of the research chemist have been obtained during the course of many years of preparation work in our petroleum organic laboratories.

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Metallizing Disk Valves and Seats Extends Service Life

ELTON STERRETT

METALLIZING, recognized as a standard and more or less routine reclamation method for the rebuilding of rotating or reciprocating cylindrical surfaces, generally has been considered by most maintenance men as unsuited for replacing worn or eroded metal on surfaces which are subject to impact or pounding during service. In this last category fall the disk-type pump valves and seats, which are alternately subjected to vigorous cross scouring of the fluid being handled and then slammed down against each other under the sudden reversal or stoppage of flow in the valve chamber.

Faced with the problem of maintaining these disk-type valves and seats in a series of pumps handling fluids under pressures up to 400 pounds, and at temperatures between 350 and 400° F., The Pure Oil Company, at its Smith's Bluff refinery, began experimenting with the refacing of these valve parts through metallizing in a department already conversant with the practice on pump rods and plungers. Undeterred by initially unsatisfactory results, the development of a technique which would stand up and which required the exercise of only two factors—care and speed—went ahead until it is now routine to reface valves and seats and obtain a service life three or more times that obtained from the initial equipment.

In a standard rebuilding on a valve seat, it is removed from the pump body casting and centered in the chuck of the metallizing lathe, emphasis being placed on the setting by so locating the part between the chuck jaws that the lathe tool will leave retaining "walls" or edges of the parent metal of approximately uniform thickness all around both seating areas—that on the rim and the one at the central seal around the valve retaining stud.

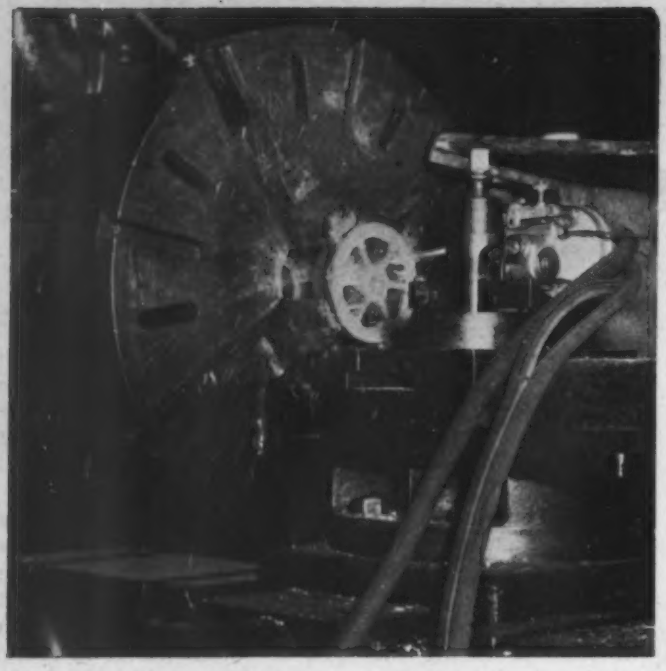
After spotting, the worn surfaces of the valve are turned down with a pointed tool, ground with its upper face sloping toward the work so as to produce a tearing, jagged cut instead of removing a smooth chip. A single pass across the work is made with the tool, recessing the area in which metal is to be deposited so that it is undercut about 3/32 of an inch.

Care is taken to see that the cutting tool is clear of oil or grease before beginning the cut, and the lathe operator is careful to keep fingers and work gloves from contact with the newly exposed metal surface, and even to keep from breathing on the work while checking the action of the lathe tool.

As soon as the grooving operation is completed the metallizing head, already mounted on its special support alongside the tool post, is connected to fuel tank supply, the exhaust fan is started to remove fumes, and deposition of new metal is begun. The lathe is run at the same speed as for removal of the metal in forming the groove, though the traverse of the "gun" is not as rapid as was that of the cutting tool across the work. First the inner area is built up so as to project at least 1/32-inch beyond the ulti-

The valve seat, accurately spotted in the lathe chuck, has been recessed to provide a holding ground for the new hard-facing metal. The tool used produces a rough, serrated finish in the metal, forming a matrix into which the droplets of sprayed metal are firmly bedded.

Set-up of the metallizing lathe, with fume catcher and eductor tube to prevent contamination by fumes from the sprayed metal. The light shown at left is to give illumination below the work while preparing recess and bringing hard-facing material to final finish.



Spraying of the hard-facing metal is done with the gun mounted on the lathe tool post, alongside the turning tool. Speed of the feed across the recess in the seat is closely gauged by the operator to give complete build-up in one pass of the gun across the work.

mate finish dimension of the seat. The head is then moved across to the outside ring, and this surface also brought up to rough-finish thickness. Both filling-in operations are done from the inside diameter toward the outside rim of the recess, so as to give better wedging of the last lap or bead of the applied metal against the relatively larger outside retaining edge of the recess.

Then, without changing the setting of the valve seat in the lathe chuck, the roughing tool is removed from the holder and a specially formed finishing point is inserted, and the deposited metal shaved off

The seat has been built up with new hard-facing metal to a height about 1/32 inch above the finish dimension. The sprayed metal adheres even to the untouched surfaces of the seat body, but will flake off or cut free readily under the tool, while a strong, resistant bond is formed in recesses.

carefully until the original surface of the seat, as shown by the retaining edges, is again attained. Since it is desired that all seating or sealing action be on the newly applied metal, no attempt is made to bring the entire face to a common surface.

Valve Rebuilding

Refacing of the valve disks is similar to that outlined step by step for the seat, except that even greater care is exercised to insure that the outer rim of the recess for new metal be as nearly uniform as possible, consistent with the condition of the valve body. As for the seat, the metal applied is 18-8, in ⅛-inch wire.

Examination of valves and seats after runs amounting to 200 percent or more of initial service periods showed no loosening of the ring of hard metal placed between the retaining edges, no flaking of the surface under impact and even, in some instances, a faint trace of the mark left by the tool when bringing the hard-metal facing down to the desired dimension. One

The finished valve seat, turned down to give a new face across the hard material, shows by the concentric lines the edges of the recess formerly cut to take the replacement. Both central and ring areas are finished to the same plane surface, to simplify valve fitting.

valve, sawed in two across the diameter, was examined for bond and one half was twisted through a 90-degree bend without loosening the applied material. Attempts to drive a half-inch cold chisel between hard metal and relatively soft body of the valve in another test failed to tear away the hard-facing material, though the jagged ridges left by the lathe tool were sheared by the sharp edge—the serrated edges remaining embedded in the matrix of 18-8 metal.

Hard-facing by metallizing of all valves and seats in this type of service is now a routine operation at the plant mentioned after an initial period of operation with parts as furnished by the manufacturer. Many instances of three- or even four-year service of hard-faced valve parts are reported, against former replacement schedules on a three-month basis. For this refinery, metallizing has proved its worth in rebuilding parts subject to fluid scour and operating impact, and the scope of its use thus greatly widened.

Oiliness and Dipole Moment of Lubricants

DR. E. H. KADMER

Translated from Oel u. Kohle by E. J. Barth, Petroleum Technologist

SUMMARY

1. Dipole nature, dipole moments and the divergence DK — n^2 as a deviation of Maxwell's formula have been described and the basis of such discussions have been reviewed. With this as basis it has been shown that for several series of pure hydrocarbons the presence of a side-chain methyl group attached to aromatic rings gives rise to electrical asymmetry and therefore polarity.

2. The determination and proof of a permanent dipole moment in the case of complicated mixtures of hydrocarbons, such as are found in the light oils and lubricants, is not of great practical significance. Such determinations yield values which represent only a cross-section or average values found for polar material more or less in dilution in the non-polar portion of the lubricant.

3. It was therefore proposed to investigate the presence of polar material after first separating it from non-polar or diluent material by means of procedures involving the use of solvents or by selective adsorption. Dipole moments were then also determined on the extracted material thus obtained. It was shown which of these types of concentrated materials give permanent dipole moments and what the nature of such material might be, especially as regards any relationships as to oiliness properties, etc.

4. The presence of permanent dipole moments in lubricating oils should in no case be used as a measure of their value as oiliness agents or in predicting their value for practical purposes. Well known substances such as rosin oil and materials found in the extracts from solvent extraction of heavy oils and which contain oxygen, sulphur and resinous hydrocarbons do not reduce friction and yet have been found to be polar in nature.

MODERN physics postulates the assumption that the sum of the positive and negative charges in a molecule concentrate as positive or negative groupings or electrical centers of gravity in the molecule; this concentration of charges is designated as a "pole." Molecules in which this concentration point of charges has no value, or is zero, are known as non-polar molecules and are said to be electrically symmetrical. Molecules which possess charge concentrations, however small in value, and separated by no more than perhaps 10^{-18} cm., are designated as double pole molecules or "dipole molecules," called "polar" for short, and are said to be electrically asymmetrical. The dipole moment (μ) is the product of the electrical charge (e) times the "pole" distance[1]: or,

$$\mu = e \times l$$

Non-polar as well as polar molecules are, of course, electrically neutral from the chemist's point of view. The reason for this is that the sum of the positive and negative electrostatic units, or charges, are equally balanced. However, if one subjects the electrically neutral molecule to an electrical field, or brings within the range of the latter, a displacement of electric charges will take place in the molecule. The result is actually a pulling apart, or separation, of the electrical charges, called "deformation." The concentration points are in the presence of such a field separated, or pulled apart, which otherwise in non-polar molecules are grouped together when they are not exposed to outside electrical forces. This is designated as "polarization" and it is said that the molecule now (influenced by external electrical forces) possesses an "induced dipole moment."

In contrast to non-polar molecules, polar molecules possess from the very beginning an everpresent and "permanent dipole moment," which remains constant and stationary. Total polarization (molecular polarization MP) is, in the presence of an electrical field, equal to the electronic polarization (PE) in the case of non-polar molecules. In the case of polar molecules, it is equal to the sum of the permanent orientation polarization (PO) and the induced "deformed" portion (PE). This can be expressed as follows:

For non-polar molecules:

$$(MP) = (PE)$$

For polar molecules:

$$(MP) = (PO) + (PE)$$

According to Lorentz and Lorenz, one can choose or use the molecular refraction (Mr) as a measure of the polarization (PE) induced by the electrical field; this can be expressed as follows:

$$(Mr) = (PE) = \frac{n^2-1}{n^2+2} \cdot \frac{M}{\alpha} = \frac{4}{3}\pi N \gamma_o$$

In the above, n is equivalent to the index of refraction, M the molecular weight, α the specific gravity, N the number of molecules in a mole of the material under investigation, ($N = 6.06 \times 10^{23}$), and γ_o is equal to the polarizability."

Debye (1) gives the following expression for permanent polarization (PO):

$$(PO) = \frac{4}{3}\pi N \cdot \frac{\mu^2}{3\kappa T}$$

In the above expression μ expresses the permanent dipole moment, κ the Boltzmann constant (1.37×10^{-16}), and T the absolute temperature.

Maxwell's expression $(DK) = n^2$, in which the dielectric constant (DK) is equal to the square of the refractive index (n), can fortunately be applied also for non-polar molecules. The above expressions should therefore be kept in mind, and their differences noted:

$$(PE) = (Mr) = \frac{n^2-1}{n^2+2} \times \frac{M}{d} \text{ and } (MP) = (PO) + (PE) = \frac{DK-1}{DK+2} \times \frac{M}{d}$$

Using both these formulas the orientation polarization (PO) is calculated as the difference: (MP) — (PE), as follows:

$$(PO) = (MP) - (PE) = \frac{M}{d}\left[\frac{DK-1}{DK+2} - \frac{n^2-1}{n^2+2}\right]$$

Based on Debye's formula, the permanent dipole moment (μ) can be calculated from the orientation polarization (PO) as follows:

$$\mu = \sqrt{\frac{9\kappa T (PO)}{4\pi N}} = \sqrt{\frac{9\kappa}{4\pi N}} \times \sqrt{(PO)T} = 0{,}0127 \times 10^{-18} \sqrt{(MP - PE)T}$$

or,

$$\mu = 0{,}0127 \times 10^{-18} \sqrt{T \times \frac{M}{d}\left[\frac{DK-1}{DK+2} - \frac{n^2-1}{n^2+1}\right]}$$

These formulas are of great value in oil analyses for evalu-

TABLE 1

Dipole Moments and Other Constants of Hydrocarbons

HYDROCARBON	d^{4}_{20}	n^{20}/D	Dk	Dk—n^2	M	MP	Mr	$\mu \times 10^{-18}$
Non-polar:								
n-pentane	0.626	1.3577	1.84	0	72	25.15	25.15	0.0
n-hexane	0.659	1.3756	1.89	0	86	29.77	29.77	0.0
n-heptane	0.684	1.3876	1.92	0	100	34.3	34.3	0.0
n-octane	0.703	1.3976	1.95	0	114	38.9	38.9	0.0
n-decane	0.730	1.4120	1.99	0	142	48.4	48.4	0.0
Cyclohexane	0.778	1.4260	2.03	0	84	27.6	27.6	0.0
decalin	0.895	1.4680	2.16	0	138	42.9	42.9	0.0
benzole	0.879	1.5014	2.25	0	78	26.2	26.2	0.0
p-xylol..e	0.861	1.4955	2.24	0	106	48.9	48.9	0.0
naphthalne	1.145	1.6140	2.60	0	128	38.8	38.8	0.0
Polar:								
l-pentene	0.641	1.3736	2.20	0.31	70	31.2	25.0	0.54
o-xylol	0.863	1.5046	2.50	0.32	106	42.0	36.7	0.52
m-xylol	0.864	1.4912	2.37	0.13	106	38.8	36.2	0.35
Toluol	0.865	1.4955	2.39	0.15	92	33.5	31.0	0.34
Ethyl benzole	0.868	1.4951	2.40	0.16	106	38.8	35.6	0.39
Methyl naphthalene	1.005	1.6180	2.79	0.17	142	52.8	49.3	0.41
Tetralin	0.975	1.5470	2.97	0.58	124	50.2	40.1	0.69

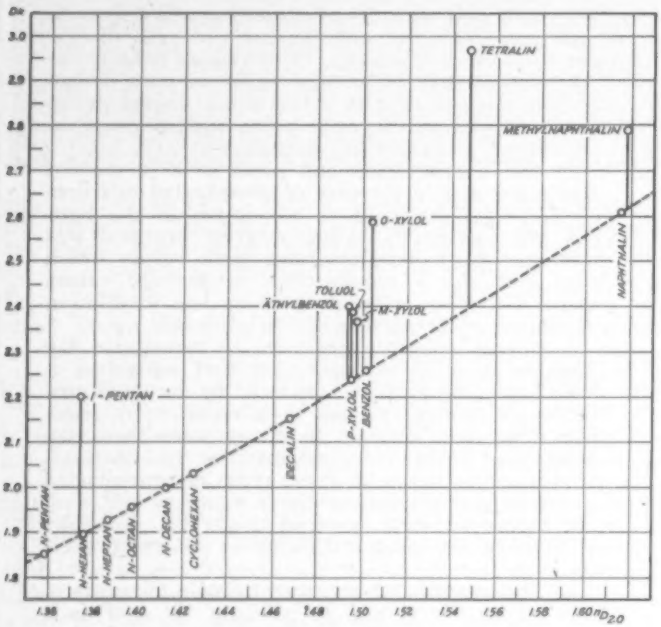


FIGURE 1

Dielectric constant and defractive index of hydrocarbons

ating the permanent dipole moment (μ); it necessitates determining the values for molecular weight, density, dielectric constant and the refractive index.

The practical determination of the dipole moment is best carried out by dissolving the oil with a non-polar solvent, such as benzol, etc. This procedure is necessary in order to exclude any possible changes in the oil due to association phenomena. The procedure was first worked out by Heinze, Marder and co-workers[3]. Their excellent contributions are to be recommended for further study. For the above calculations Debye has given the following formula:

$$(MP)_m = \frac{DK-1}{DK+2} \times \frac{M_1 f_1 + M_2 f_2}{d} = (MP)_1 f_1 + (MP)_2 f_2$$

$$\text{Incidentally, } f_1 = \frac{m_1}{(m_1+m_2)} \text{ and } f_2 = \frac{m_2}{(m_1+m_2)}$$

Here, (MP) signifies the total polarization of the oil-solvent mixture; (DK) the dielectric constant of the mixture; d specific gravity of the mixture; M_1 the molecular weight of the dissolved substance; M_2 molecular weight of the solvent, f_1 the molal quantity of the dissolved substance and f_2 that of the solvent.

Next in importance in our considerations becomes the divergence or deviation of (DK) in relation to the square of the refractive index as applied to definite chemical substances, as well as with well-defined individual groups. If one plots (DK) as the ordinate and the index of refraction (n) as the abscissa, as has been done in Figure 1, it will be seen that a very uniform curve is obtained for Maxwell's relation, $(DK) = n^2$. All electrically symmetrical and therefore non-polar hydrocarbons will lie on this curve and coincide with values found in the practical determination of (DK) and (n); electrically asymmetrical hydrocarbons—those therefore which are permanently polar—show a consistent difference $(DK) - n^2$, according to the definition of dipole moment.

The results plotted in Figure 1 below show that the normal paraffins, benzol, cyclohexane, naphthalene, and completely hydrogenated naphthalene (Decalin) are non-polar. Side chains consisting of methyl groups attached to rings (toluol, o- and m-xylol) methyl naphthalene produce electrical asymmetry; methyl groups, however, in the para position as in p-xylol again show complete symmetry. Tetraline, a partially hydrogenated substance, is quite polar, as is pentene, which is typical for the olefines.

Table 1 shows the characteristic values and necessary constants for the hydrocarbons plotted in Figure 1.

The simple and clear-cut picture as presented in Figure 1 is not as clearly defined, however, in the case of hydrocarbon mixtures as found in light oils and the lubricants. Early in a discussion of this kind, one should acknowledge the fact that in determining dipole moments of lubricating oil (where an already existing permanent dipole is present) the effect of the dipole nature of some specific oiliness agent or otherwise active group constituent will indeed show its presence in the oil. The determination itself, however, is only a value obtained on the oil itself—that is, the active groups in any oil are always in a highly diluted form as it were; such values at best represent only a cross section of the whole oil.

As a matter of fact, the measurements of permanent dipole moments are not highly significant when applied, for instance, to mineral-oil raffinates. Here, the values are very low (maximum 0.4×10^{-38}) and the Maxwell relation $DK = n^2$ holds good in practically all these cases. Nevertheless, there are many types of lubricants as will be shown below which contain small amounts of material of very high dipole moment; it would, however, be erroneous to classify these dipole constituents at once as groups or hydrocarbons possessing some special oiliness characteristic. This view has been held to be consistent with our present knowledge of oiliness agents from practical field experience.

In the case of lubricants one is really not interested whatever with values of dipole moments thus shown to be merely an average value for the oil as a whole; it becomes necessary to separate polar material from non-polar oily constituents by some method of separation and concentration which can be easily carried out. In regard to such methods, it is, of course, known that it is not possible to separate definite single hydrocarbons present in lubricating oils into individual fractions, so that one is limited at best to separate the oil merely into various group constituents.

As is known from practical refining operations of recent years, such a separation is easily made by the use of solvent extraction, obtaining a paraffinic "raffinate" and an impure material or oil called "extract." One must keep well in mind, however, that such solvents as alcohol, acetone, analine, nitrobenzol, furfural, etc., show characteristic high dipole moments, and must be carefully and thoroughly removed from both the raffinate and the extract before analyses are made. Where it is desirable to circumvent the use of polar solvents one might well, in many cases, make use of selective adsorption, using aluminum oxide or the activated clays. This procedure has given excellent results in many cases. It has been termed a "Chromato-Graphical" method[5], and is a modification of the clay adsorption procedure of Suida and Poll.[4]

Table 2 gives data of the relationship between DK and n^2, and the dipole moments of many types of lubricant materials.

A study of Table 2 brings out the fact that nitrobenzol is a powerful solvent for removing all types of polar material from a raffinate material, as is shown in oils No. 1 and No. 2. The permanent dipole moment of both these raffinates is practically zero. In order to magnify the action of selective solvents still further for our discussion, attention is called to experimental oils 3R-3E and 4R-4E. It is seen that polar constituents are entirely concentrated in the extract so that this material shows a very definite permanent dipole moment. The structure of the compounds found in such extract can be said, therefore, to be electrically asymmetrical and the groups present are probably thoroughly distributed throughout the extract. It is, of course, possible that there are also present at the same time in the

TABLE 2

Dipole Moments and Other Constants of Oils and Oiliness Materials

No.	OIL	$d^4/_{20}$	N^{20}/D	E/50C.	m	An. Pt.	M. Wt.	DK	DK-n^2	MP	Mr	$\mu \times 10^{-18}$
1	Nitrobenzol Raffinate	0.871	1.4818	4.25	3.52	111	430	2.186	—0.009	139.6	140.5	0.00
2	Nitrobenzol Raffinate	0.881	1.4884	10.4	3.48	119	501	2.211	—0.004	163.0	163.6	0.00
3R	SO_2—Raffinate	0.867	1.4772	1.83	4.16	91	306	2.177	—0.005	99.5	100.0	0.00
3E	SO_2—Extract	1.005	1.5693	2.70	4.66	4	270	3.103	+0.640	110.7	88.3	1.04
4R	SO_2—Raffinate	0.880	1.4900	2.18	3.98	89	319	2.214	—0.002	100.7	100.8	0.00
4E	SO_2—Extract	1.009	1.5727	3.07	4.82	7	283	3.224	+0.751	119.0	92.2	1.13
5	Acid treated oil	0.915	1.5105	12.6	3.72	94	459	2.293	+0.012	151.0	150.0	0.22
6	Lube oil, med. ref'd	0.942	1.5195	24.0	4.29	87	422	2.324	+0.014	137.0	136.0	0.22
7	Synthetic Lube oil*	0.864	1.4813	.....	....	..	792	2.176	—0.018	258.2	261.1	0.00
8	Lube ref'd*	0.889	1.4924	.....	....	..	426	2.264	+0.037	142.0	139.1	0.37
8A	Lube Oil, aged or oxid'd*	0.894	1.4944	.....	....	..	492	2.327	+0.094	167.4	160.3	0.58
9	Tech. Oleic Acid	0.893	1.4615	2.28	3.17	..	282	2.743	+0.607	116.3	86.8	1.18
10	Rapeseed Oil*	0.923	1.4743	.....	....	..	854	3.305	+1.131	401.9	250.0	2.59
11	Peanut Oil*	0.914	1.4708	.....	....	..	754	3.129	+0.966	324.3	230.4	2.30
12	Olive Oil*	0.913	1.4692	.....	....	..	720	3.120	+0.961	326.7	219.2	2.25
13	Castor Oil	0.958	1.4760	17.4	3.56	..	928	4.670	+2.490	533.0	276.0	3 49
14	Cottonseed Oil	0.919	1.4720	3.64	2.82	..	792	3.150	+0.984	359.0	241.0	3.38
15	Rapeseed Oil (German)	0.909	1.4717	4.40	2.80	..	892	2.834	+0.668	373.0	275.0	2.17
16	Rapeseed Oil, blown	0.962	1.4800	36.0	3.37	..	...	4.120	+1.930	.....	.....	....
17	Cod Oil, brown	0.919	1.4745	3.60	3.03	..	890	3.930	+1.766	478.0	272.0	3.12
18	Lignite Tar Oil*	0.928	1.5189	.....	....	..	318	.....	.....	.....	104.1	1.20
19	Rosin Oil, double ref'd	0.971	1.5378	2.93	5.25	..	...	2.670	+0.305	.....	.....	....
20	Lube Oil, refined*	0.881	1.4908	.....	....	..	506	2.228	+0.005	166.8	166.2	0.16
20A	Lube Oil +4 percent Rapeseed*	0.883	1.4899	.....	....	..	515	2.268	+0.048	173.2	168.8	0.45
20B	Lube Oil +8 percent Rapeseed*	0.885	1.4894	.....	....	..	523	2.308	+0.090	179.6	171.3	0.63
20C	Lube Oil +12 percent Rapeseed*	0.886	1.4887	.....	....	..	532	2.345	+0.129	185.9	173.2	0.82

REMARKS:—E/50C., the viscosity in Engler degrees at 50 C., m—the slope of the viscosity curve; oils designated with * are taken from Heinze & Marder: see [2].

extract materials which may be active oiliness agents but the term "oiliness" should not be used as an equivalent for the term "permanent dipole moment" in the case of lubricants, merely judging from experiments as No. 3 and No. 4.

An ordinary refined oil as obtained with sulphuric acid, shown as oil No. 5, shows a very definite dipole moment and it is a question for future research whether this permanent dipole moment may not be due to some content of oil resins which may well be present in poorly refined or partially treated motor oils, as the above.

It is most likely that polar molecules will be found in the oil resins since the latter contain on the average some 0.7-2.4 percent sulphur and 1-7 percent of oxygen. In the case of lubricants with a viscosity of 2-20 Engler degrees at 50°C. one will usually find a content of oil resins from 1.5-6 percent. The resin cntent of mineral oils refined by solvents is probably 0.5-2 percent lower. These groups are present to the extent of 10-17 percent in filtered bright stocks and in residual cylinder oils. It is therefore important and of great practical value to remove these resins from a raffinate oil, or acid-treated oils; and then to determine quantitatively the concentration of polar material by the use of the solvent-extraction method using any of the above-mentioned solvents or other standard solvents employed in modern refinery technology.

Oil No. 6 is a very viscous raffinate and has been fairly well solvent-extracted. It presents no further interest as far as identifying individual constituents. Oil No. 7 is a synthetic lubricant and as such is non-polar. It is said that these particular oils are "dead" when it comes to oiliness characteristics—in other words, devoid of lubricity—but that they develop definite oiliness characteristics after being used for some period of time. It seems that this statement first made without laboratory determination does find corroboration now in practice. It has now been found that these oils during natural and especially after artificial ageing (oxidation), actually do develop acidity and show an increase in viscosity. It would therefore be of great interest to determine the development of a permanent dipole moment of such synthetic oils while they are undergoing artificial ageing or oxidation. Any artificial ageing of mineral oils (which is usually accompanied by a partial oxidation of very reactive hydrocarbon groups) always results in an accumulation or increase in the permanent dipole moment of the oil, due to the formation of polar material. This has already been shown and proven by Heinze, Marder and others.[2] The pair of Oils 8 and 8A in Table 2 seem to bear this out. Technical red oil (Oil No. 9) is contaminated with only traces of unsplit triolein; the permanent dipole moment was found to be 1.18 and DK as 2.743. In order actually to evaluate this result correctly there are presented in Table 3 the important constants for the common fatty acids.

TABLE 3

Constants of Fatty Acids

ACID	Formula	m(m.wt.)	$d^4/_{20}$	n^{20}/D	DK	$\mu \times 10^{-18}$
Formic	H—COOH	46	1.220	1.3714	58.5	1.13
Acetic	CH_3—COOH	60	1.049	1.3699	9.7	0.96
Lactic	CH_3—CH(OH)—COOH	90	1.240	1.4315	23.0	1.42
Propionic	CH_3—CH_2—COOH	74	0.992	....	3.15	....
n-butyric	C_3H_7—COOH	88	0.964	1.3976	3.00	0.83
Tartaric	HOOC—CH(OH)—CH(OH)—COOH	150	1.760	....	36.00	....

While the DK values are high for the lower acids and oxy-acids, the dipole moment varies only between from $0.8\text{-}1.4 \times 10^{-18}$. In the case of lactic acid, tartaric acid, ricinoleic and similar acids, as well as dioxystearic acid, the presence of the OH group becomes very pronounced due to the electrical asymmetry which is developed by these groups. In such cases the DK value is high. All fatty oils are characterized by rather high permanent dipole moments. It is noticeable that the triglycerides show a much stronger asymmetrical characteristic than do their free fatty acids.

Heinze and Marder investigated also a lubricating oil made from lignite tar—oil No. 18—the manufacture of which was described by Marder and Mertz.[5] The high dipole moment which was naturally expected in this case should be looked upon as due more to the presence of asymmetrical resinous material containing oxygen and sulphur than to any desirable presence of some unknown oiliness agent, since after all, this type of oil represents only a partially refined tar oil

The investigation of Oil No. 19, which is a double-refined absolutely neutral rosin oil, actually used as a transformer oil, shows that resinous substances do manifest electrical asymmetry. At the time a determination of the molecular weight had ben omitted so that the value for the dipole moment is not known.

The divergence between DK and n^2 is quite pronounced in a case of this rosin oil and points to a definite content of polar material. It can be well pointed out, however, in the case of this oil, that its polar nature is not at all in line with the poor showing given by this oil in actual friction tests. The relatively simple measurement for obtaining values of "rubbing friction," as a reciprocal of oiliness or lubricity, has shown this to be true. The measurements are made in the oil-testing machine according to Thoma.

Table 4 gives a resume of oiliness measurements of various oils discussed so far when tested by the Thoma machine. The rubbing friction is given in grams for a definite comparative viscosity of 40 cp and of course it is known that the oiliness, or lubricity, is very good or excellent where the value for the rubbing friction (R) is low. The determination of the rubbing friction takes place under constantly increased bearing pressures.

One will notice that mineral-oil raffinates show friction values for R from 30-40 units, while much more favorable values of 15-17 are found for the fatty oils and fatty acids. The partially refined rosin oil, however, shows the exceedingly high value of 51.8. It can be said that obviously the electrical asymmetry in certain oil molecules is not only the result of the presence of some oiliness materials but also can

TABLE 4

DK—n^2, Constant u, and Rubbing Constant R

No.	OIL	DK—n^2	$\mu \times 10^{-18}$	R
1	Nitrobenzole Raffinate	−0.009	0.0	30.5
2	Nitrobenzole Raffinate	−0.004	0.0	30.2
3	SO_2 spindle-oil Reffinate	−0.005	0.0	32.6
4	SO_2 spindle-oil Reffinate	−0.002	0.0	35.5
5	H_2SO_4 treated oil (motor-oil)	+0.012	0.22	35.8
6	Lube-oil, med. Ref'd	+0.014	0.22	40.0
7	Synthetic lube oil	−0.018	0.00	28.20
9	Tech. oleic acid	+0.607	1.18	15.4
10	Rapeseed oil	+1.131	2.59	16.4
12	Olive oil	+0.961	2.25	15.9
13	Castor oil	2.490	3.49	17.0
17	Cod oil (brown)	1.766	3.12	16.0
19	Rosin-oil, double ref'd	0.305	....	51.8

be due to resinous material, or hydrocarbons containing oxygen and sulphur, and also products of ageing or oxidation. Tarry matter and crankcase sludge should also be grouped with this latter type of material.

It appears that there is apparently no relation whatever between dipole moment and lubricity, nor can it be said that the dipole moment in lubricants is simply or directly related to beneficial oiliness hydrocarbons. As a matter of fact, one can go still further and pose the question whether the dipole moment has anything whatever to do with lubricating values or oiliness characteristics of lubricant oils.

In the case of fatty oils the dipole moment is, after all, only the expression of the electrical asymmetry of the triglycerides. It is unfortunate that the characteristic oiliness properties of fatty oils should incidentally be an expression of their electrical asymmetry. In contrast to this, it is known that free fatty acids are very much more reactive toward metallic surfaces and are therefore stronger oiliness agents than are the neutral fatty oils. It is also known that the acid type or acidic fatty oils take a position about midway between the two mentioned above, as far as their oiliness characteristics are concerned. The permanent dipole moment of the free fatty acids is, therefore, as can be readily seen, only one third of that of the fatty oils, where the glycerine is substituted with three fatty-acid radicals. This fact appears to contradict our knowledge that the fatty acids do show very much greater oiliness characteristics.

The work of Heinze and Marder[2] necessitates a consideration of further judgment of these statements in view of their interesting work in this subject. For instance, Oil No. 20 is a practically non-polar lubricant. The addition of rapeseed oil to this raffinate appears to increase the dipole moment in the mixture at a much greater rate than is found by calculation. Conversely, if one calculates the dipole moment of the straight rapeseed oil from the dipole moment of a mixture of 4.8-12 percent of fatty oil in mineral oil, one obtains the ideal rapeseed-oil value of $\mu = 7$ to 4.6×10^{-18}.

It is of importance next to consider the constants of the above oils and their meaning as applied to their practical applications in the field of reducing friction and to judge these oils, for instance, as lubricants for cutting and other uses, such as in the metal-working industry.

The metal-working industry employs as one of the factors to determine oiliness and E. P. values, the term called "tool life"—the length of time during which the cutting tool (applied to the metal to be machined) properly functions before serious tool collapse occurs under the action of various oiliness lubricants; this criterion as is used in the metal-working industry has become a well-nigh established synonym for oiliness or lubricity. As in other fields of applied science, the actual use of oiliness agents, fatty oils, extracts, etc., in plant practice becomes in the last analysis the final test for theoretical considerations and the further basis for accumulating experimental data. The duration of useful life, or "tool life," of the cutting tool is expressed in terms of the number of parts finished, or turned out, by that tool, in relation to the content of rapeseed oil in the cutting oil. When using pure rapeseed oil several thousand metal pieces could be finished before the cutting tool had to be reground or replaced.

This value was the highest obtained in a total of many experiments using straight rapeseed oil, and no higher figures were found in further experiments. The average of these values thus obtained with pure rapeseed oil was therefore made equal to 100 percent, as is shown in Figure 2. When using a very pure, highly refined lubricating oil of about 3 E. viscosity at 50°C, tool-life, as expressed in number of metal parts finished, was found to be very low; it comprised a bare 100 finished work-pieces and therefore barely 1 percent. By the addition of very small amounts of rapeseed oil to this lubricant tool-life increased very much more than one would have found by straight calculation of the mixture; the values plotted in Figure 2 show the actual results obtained from these practical tests.

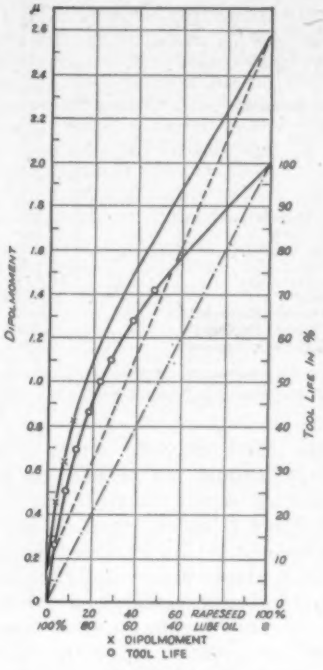


FIGURE 2

Relationship between dipole moment of a cutting oil and tool life of a rapeseed-lube oil mixture.

It is not very clear, therefore, if there is any relationship between the values of dipole moments of mineral-oil-rapeseed mixtures and the lubricity or oiliness properties in the case where such mixtures are used, as in the metal-working industry. In spite of this, there may nevertheless be some false conclusions embodied in such statements. So far it has been shown that the dipole moment of mixtures or diluted oils with other constituents is only an average or cross section of the many chemical groups present as determined by definite or known procedures. In the case of mixtures of mineral oils with rapeseed oil the dipole moment of the mixtures parallels to some extent the oiliness effect of the rapeseed oil, but should not be considered a measure of oiliness or lubricity.

In recent years it has become common practice here and abroad to add highly polar material to lubricating oils in order to increase oiliness characteristics; besides using animal and vegetable oil for this purpose, new types of chlorinated, and sulphonated products have been employed to a very large extent where prices warrant it, and again, more recently, definite chemical substances have come into use as oiliness addition agents, especially products such as the aromatic phosphates, aliphatic nitriles, as well as substances showing high polarity; these substances have given excellent results in practice.

One still awaits much practical evidence and further experimental data as final proof concerning the value for many of these chemical derivatives as oiliness agents. Many of these materials show chemical action on metallic surfaces much more pronounced than that found for the animal and vegetable oils. It becomes therefore all the more doubtful whether there is any experimental or practical relationship between the dipole nature of oils or chemical groups and their oiliness effects.

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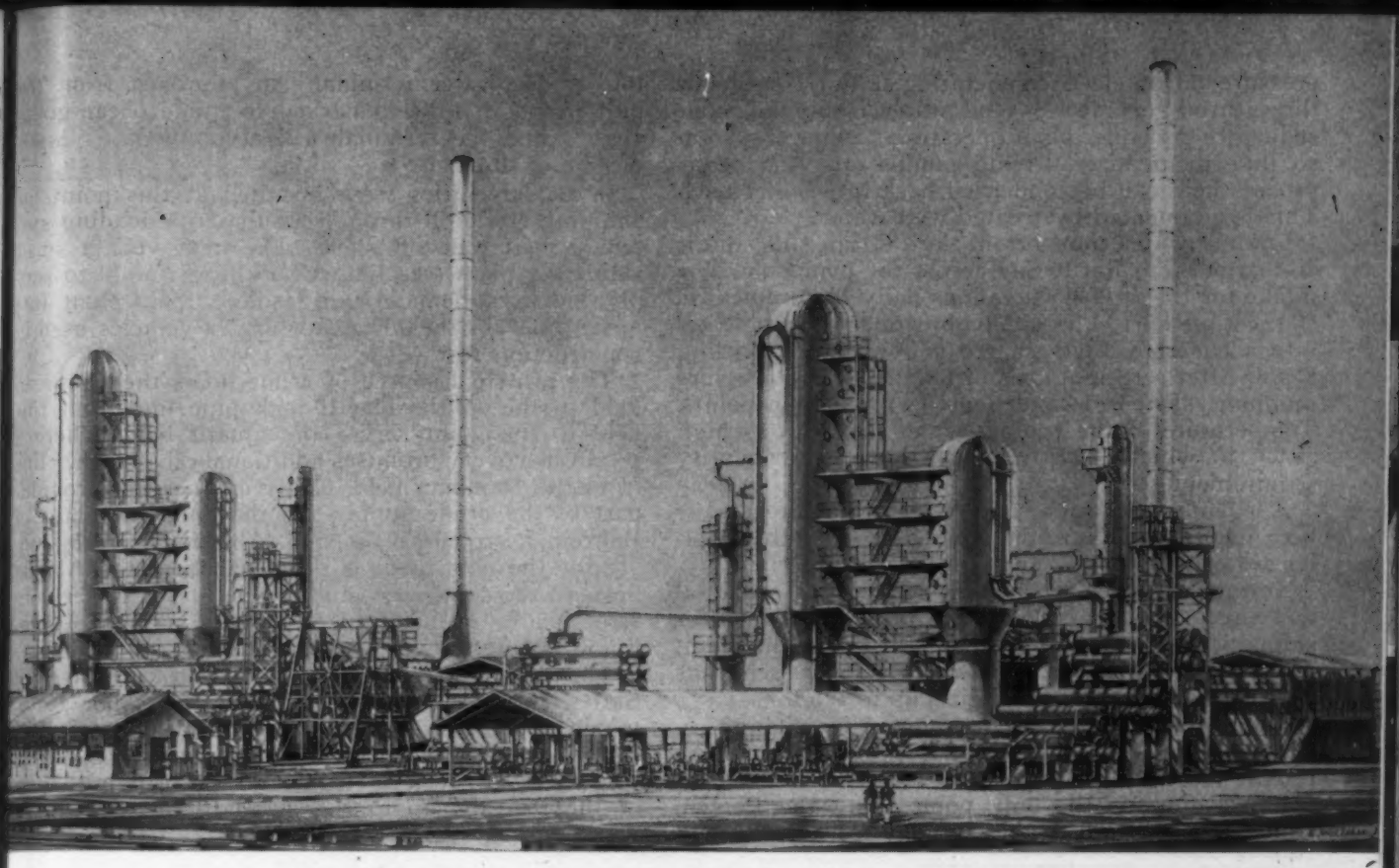


Two crude stills, each 25,000 barrels daily capacity, will process Saudi Arabia oil. One of these units will put the new plant of Arabian American Oil Company in operation in September. The other will be completed late this year.

Stills and Towers Take Some Space From Sand Dunes on Shore Of the Persian Gulf

BY THE end of the year the new 50,000-barrel refining plant of Arabian American Oil Company will be in operation at Ras Tanura on the Persian Gulf. One distillation unit, 25,000 barrels daily capacity, is due to go on stream in September and a second in December. The plant will have additional facilities for thermal reforming the gasoline cut off of the total 50,000 barrels daily capacity.

The Ras Tanura installation is one of the foreign projects given approval for American-made equipment early in 1944. Since then the site, where a 3000-barrel plant already was operating, has been provided with living quarters and the processing units put in place. Part of the project includes loading facilities for tankers.

The plant will finish motor fuel, diesel fuel and burning oils down to fuel oil.

The new plant is in the area of the enlarged plant of Bahrein Petroleum Company, Bahrein Island, where fluid catalytic cracking as well as alkylation facilities have been added to permit finishing fighting-grade aviation gasoline. The two projects are under the same ownership, The Texas Company and Standard Oil Company of California.

Crude oil for the two plants comes from fields on the Arabian mainland, where stabilizing facilities also remove sulphur compounds.

Processing units of the Ras Tanura plant consist of two crude stills with fractionating equipment. Straight-run gasoline from these units is further processed in two thermal-reforming units. Tankage and equipment for treating and blending make up the processing facilities.

Construction had to be carried on under unusual conditions. The area had no modern living facilities; its terrain is sand; and it has excessively high temperatures. Consequently much of the early work involved provision of storage, living quarters, refrigeration for food and the construction of roads. Only sand and gravel were at hand as building materials. The plant site was raised to six feet above sea level by moving material from nearby dunes and by dredging from the bay.

While field preparation was progressing processing equipment was under fabrication in the United States. Limited facilities at the site made it necessary to prefabricate as much of the piping, vessels and furnaces as shipping facilities would permit. Electrical units were unitized to facilitate setting up at the site.

Steam is generated in three boilers at 650 pounds

pressure and an electric generating station consists of three turbo-generators. Well water is limited, consequently the boiler plant operates as a closed system so that steam after driving pumps and serving as process heat can be condensed back into boiler feed. This is augmented by treated well water.

Cooling water comes from the Persian Gulf and it discharged into Barut Bay across the peninsula. The intake for the 70,000,000 gallons daily requirement is 600 feet offshore. Low-lift pumps raise the sea water into a concrete ditch so it can flow into a settling basin. After screening it is picked up by the pressure pumping system and delivered to cooling points. Temperature of the cooling water may run as high as 95° F., which is partly responsible for the quantity requirement.

Adequate separation and recovery facilities have been incorporated into the sewer system so that cooling water will not contaminate Barut Bay.

Storage facilities for 4,000,000 barrels of crude oil and finished products have been provided. Tanks for shipping are at the terminal six miles from the plant. The wharf, which accommodates four vessels, has facilities for unloading materials up to 125 tons.

Shop facilities have been equipped for making repairs to some of the marine equipment because of the remote location.

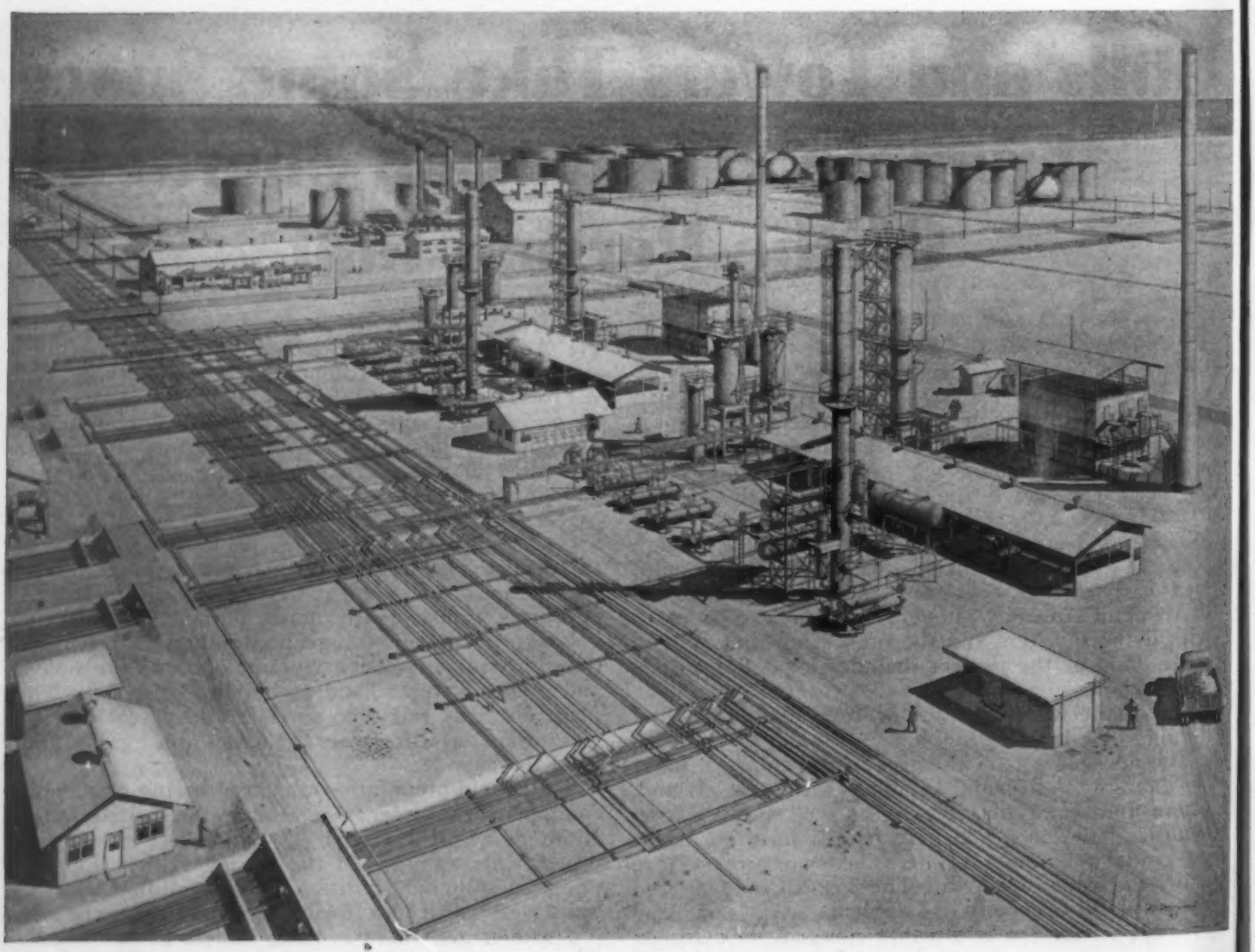
Ras Tanura is the only point along the Persian Gulf coast of Saudi Arabia suitable for development into a deepwater terminal. An approach from the gulf proper has been marked to guide ocean-going vessels and the terminal will accommodate vessels of 35-foot draft.

In 1939 facilities were installed at this point for shipping crude oil through a submarine loading system, a half mile off shore. The next year a small skimming plant was built near this terminal to supply the local demand for gasoline. This plant furnished fuel for the 400 motor-driven vehicles used in construction work.

The principal source of crude oil is the Damman field to the south. The 10-inch pipe line from this field to the point serves the Quatif field, where a recent discovery promises additional oil. Another line from the Damman field, partly submerged, provides part of the crude supply for the enlarged plant of Bahrein Petroleum Company. Additional crude supply for the new plant is promised from the Abqaiq field, to the southwest, and a pipe line is under construction to connect this discovery with the main line pipe-line system of the area.

The skilled force came to the job from the United States and from other countries. The labor force, which reached as high as 7000 during construction, had to be recruited from the coastal areas. Training courses have been instrumental in bringing some of these Arabs up to the standard of semi-skilled workmen.

Exposed piping was incorporated in the design of the two thermal reforming units, which will finish the gasoline cuts from the pipe stills into motor fuel.



Demand for Oils 10 Percent Higher Than Last Year

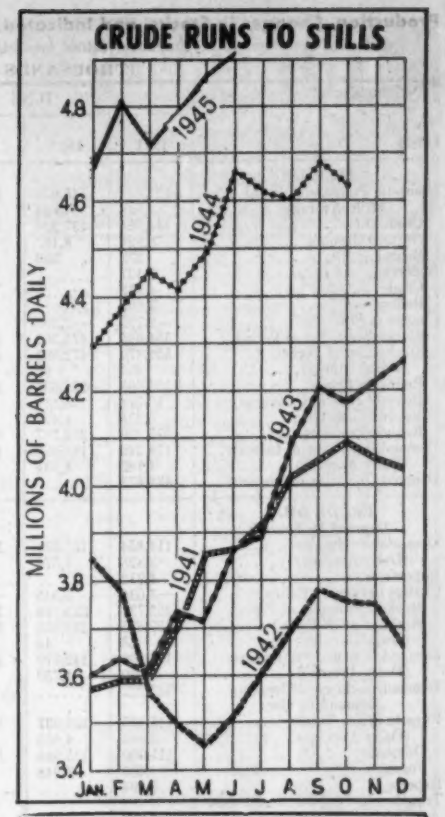
L. J. LOGAN

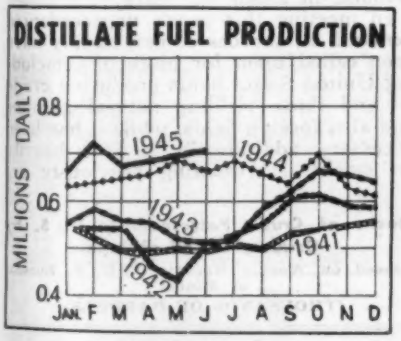
FOLLOWING last year's record-breaking operations in meeting similarly great demand for petroleum products, the industry this year has further increased the production, processing, and distribution of oils, and again will set new records in most categories for 1945.

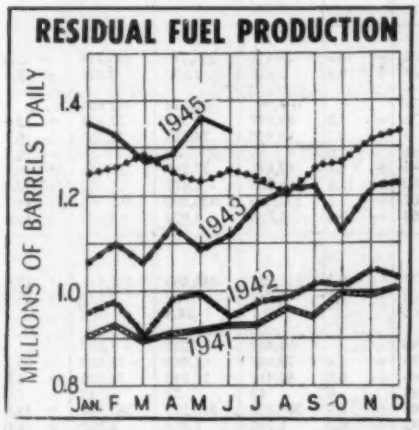
In the first half of this year the total demand for all oils not counting imports averaged 5,261,000 barrels daily, an increase of 9.6 percent over the 4,800,000 daily needed in the six months of 1944. Inclusive of imports, the increase in demand over last year probably would be above 10 percent, for imports are running higher than last year. United States imports are mostly crude oil and fuel oils, and although figures on receipts are censored, it is understood that crude imports have been running around 175,000 barrels daily this year against about 125,000 barrels daily average in 1944, while imports of fuel oils probably have been of similar proportions to those of crude.

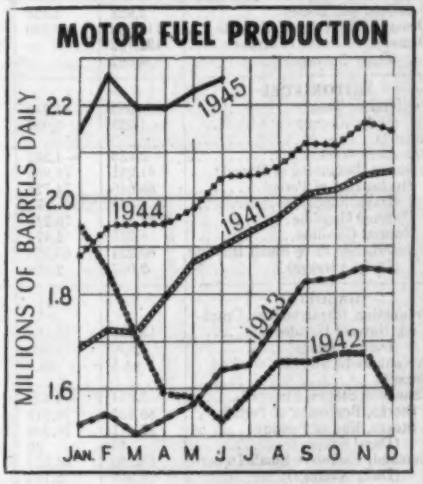
It is indicated, therefore, that total demand for all oils, as measured by domestic production of crude oil and other petroleum liquids, changes in stocks, and minimum probable imports, averaged around 5,550,000 barrels daily for the first six months of 1945, or on the basis of over 2,000,000,000 barrels annually for the first time in history. For the whole year 1944 total demand was 1,879,264,000 barrels, having averaged 5,135,000 barrels daily (Bureau of Mines data).

The great magnitude of this year's indicated demand for all oils, at about 2 billion barrels annually or 5,500,000 barrels daily, is emphasized when it is









Runs to Stills and Percent of Refinery Capacity Used, June and First 6 Months, 1941, 1944, 1945

Runs from Bureau of Mines, except May and June, 1945, from American Petroleum Institute. Capacities from American Petroleum Institute

(THOUSANDS OF BARRELS)

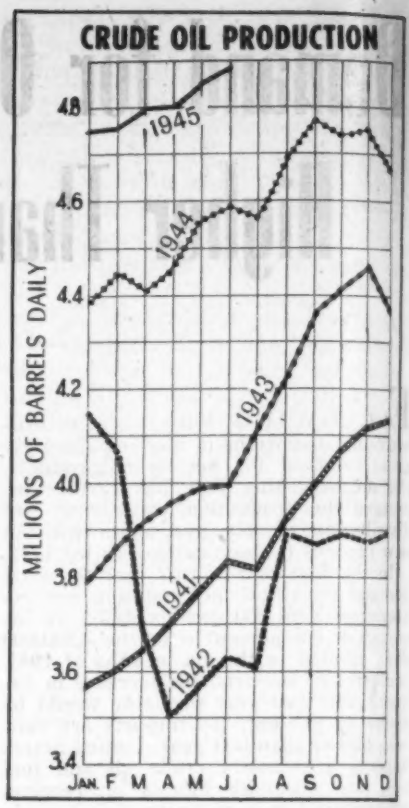
REFINING DISTRICT	CRUDE RUNS IN JUNE: Total Amount Run				CRUDE RUNS IN JUNE: Daily Average Run			REFINING CAPACITY AND USE JUNE: Daily Capacity			REFINING CAPACITY AND USE JUNE: Percent Capacity Used			TOTAL AMOUNT CRUDE RUN TO STILLS, FIRST 6 MONTHS			
	June, 1941	June, 1944	June, 1945	% Diff. '44-'45	June, 1941	June, 1944	June, 1945	June, 1941	June, 1944	June, 1945	June, 1941	June, 1944	June, 1945	January to June, 1941	January to June, 1944	January to June, 1945	% Diff. '44-'45
Combined East Coast—Southwest	57,560	73,179	76,253	+ 4.2	1,919	2,439	2,542	2,259	2,518	2,744	84.9	96.9	92.6	343,847	415,601	446,450	+ 7.4
East Coast	16,955	.....	22,415	.....	565	....	747	643	....	791	87.9	....	94.4	101,988	.....	133,010	.....
Inland Texas	5,551	.....	7,204	.....	185	....	240	280	....	330	66.1	....	72.7	32,102	.....	43,347	.....
Texas Gulf Coast	28,482	.....	35,858	.....	950	....	1,195	1,071	....	1,237	88.7	....	96.6	171,374	.....	209,334	.....
Louisiana Gulf Coast	4,448	.....	8,195	.....	148	....	273	164	....	260	90.2	....	105.0	24,859	.....	46,197	.....
North Louisiana and Arkansas	2,124	.....	2,581	.....	71	....	86	101	....	126	70.3	....	68.3	13,524	.....	14,562	.....
Appalachian	4,491	4,471	4,750	+ 6.2	150	149	158	156	177	196	96.2	84.2	80.6	25,924	27,676	28,944	+ 4.6
District No. 1	.....	.....	3,093	.....	....	....	103	....	....	146	....	....	70.5	.....	.....	18,102	.....
District No. 2	.....	.....	1,657	.....	....	....	55	....	....	50	....	....	110.0	.....	.....	10,842	.....
Indiana, Illinois, Kentucky	21,225	23,193	22,751	— 1.9	707	773	758	743	824	857	95.2	93.8	88.4	118,707	137,410	140,556	+ 2.3
Oklahoma, Kansas, Missouri	10,831	11,064	11,744	+ 6.1	361	369	392	420	418	469	86.0	88.3	83.4	60,578	64,282	69,450	+ 8.0
Rocky Mountain	2,924	3,496	4,020	+15.0	97	117	134	121	154	172	80.2	76.0	77.9	15,805	19,754	22,786	+15.3
District No. 3	.....	.....	365	.....	....	....	12	....	....	13	....	....	92.3	.....	.....	2,149	.....
District No. 4	.....	.....	3,655	.....	....	....	122	....	....	159	....	....	76.7	.....	.....	20,637	.....
California	18,904	24,534	28,403	+15.8	630	818	947	836	817	994	75.3	100.1	95.3	103,802	145,137	160,100	+10.3
Total United States	115,935	139,937	147,921	+ 5.7	3,864	4,665	4,931	4,535	4,908	5,432	85.2	95.0	90.7	668,663	809,860	868,286	+ 7.2

Production, Changes in Stocks, and Indicated Demand for Petroleum and Principal Products

Based on Data from U. S. Bureau of Mines for 1941 and 1944; on American Petroleum Institute for 1945

(THOUSANDS OF BARRELS)

ITEM	JUNE 1941	JUNE 1944	JUNE 1945	JUNE % Diff. '44-'45	FIRST 6 MONTHS 1941	FIRST 6 MONTHS 1944	FIRST 6 MONTHS 1945	FIRST 6 MONTHS % Diff. '44-'45
ALL OILS								
Domestic Production, Total	121,451	145,621	156,016	+ 7.1	705,237	862,468	927,691	+ 7.6
(Daily Average)	4,048	4,854	5,200	+ 7.1	3,896	4,739	5,125	+ 8.1
Crude Oil	114,854	137,234	146,476	+ 6.7	666,098	813,540	870,314	+ 7.0
Natural Gasoline	6,324	8,187	9,300	+ 13.6	37,403	47,728	55,937	+ 17.1
Benzol	273	200	240	+ 20.0	1,736	1,200	1,440	+ 20.0
Imports	7,427	.....	.....	.....	43,059	.....	.....	.....
Crude	4,332	.....	.....	.....	22,014	.....	.....	.....
Refined	3,095	.....	.....	.....	21,045	.....	.....	.....
Change in Stocks	—2,795	—2,399	+285	.....	—11,407	—11,093	—24,609	.....
Stocks Beginning of Period	554,665	475,392	452,195	— 4.9	563,277	484,086	477,089	— 1.4
Stocks End of Period	551,870	472,993	452,480	— 4.3	551,870	472,993	452,480	— 4.3
(Days' Supply)	133	96	87	— 9.4	139	98	86	— 12.5
Refinable Crude	259,695	229,631	220,781	— 3.9	259,695	229,631	220,781	— 3.9
Heavy Crude in California	10,711	6,118	4,940	— 19.3	10,711	6,118	4,940	— 19.3
Natural Gasoline	6,235	4,477	5,050	+ 12.8	6,235	4,477	5,050	+ 12.8
Refined Products	275,229	232,767	221,709	— 4.7	275,229	232,767	221,709	— 4.7
Demand, Exclusive of Imports	124,246	148,020	155,731	+ 5.2	716,644	873,561	952,300	+ 9.0
(Daily Average)	4,142	4,934	5,191	+ 5.2	3,959	4,800	5,261	+ 9.6
Demand, Inclusive of Imports	131,673	.....	.....	.....	759,703	.....	.....	.....
CRUDE OIL—Demand by Source:								
Domestic Production	114,854	137,234	146,476	+ 6.7	666,098	813,540	870,314	+ 7.0
(Daily Average)	3,828	4,574	4,883	+ 6.7	3,680	4,470	4,808	+ 7.5
Imports	4,332	.....	.....	.....	22,014	.....	.....	.....
Change in Stocks (Refinable)	—3,036	— 5,545	—2,944	.....	—5,014	12,131	—81	.....
Stocks, Beginning of Period	262,731	235,176	223,725	— 4.9	264,709	241,762	220,862	— 8.6
Stocks, End of Period	259,695	229,631	220,781	— 3.9	259,695	229,631	220,781	— 3.9
(Days' Supply)	66	48	44	— 8.3	70	51	46	— 9.8
Demand, Exclusive of Imports	117,890	142,779	149,420	+ 4.7	671,112	825,671	870,395	+ 5.4
(Daily Average)	3,930	4,759	4,981	+ 4.7	3,708	4,537	4,809	+ 6.0
Demand, Inclusive of Imports	122,222	.....	.....	.....	693,126	.....	.....	.....
Demand by Use:								
Runs to Stills, Total	115,935	139,937	147,921	+ 5.7	668,663	809,860	867,476	+ 7.1
(Daily Average)	3,864	4,665	4,931	+ 5.7	3,694	4,450	4,785	+ 7.5
Domestic	111,500	135,989	142,521	+ 4.8	646,066	791,234	837,404	+ 5.8
Foreign	4,435	3,948	5,400	+ 36.8	22,607	18,626	30,072	+ 61.4
Exports	3,894	.....	.....	.....	15,896	.....	.....	.....
Transfers to Fuel Oil Stocks, used as Fuel and Losses	2,923	2,328	2,010	— 13.5	9,762	16,069	12,567	— 21.8
Demand, Exclusive of Exports	118,858	142,260	149,931	+ 5.4	678,425	825,929	878,578	+ 6.4
Demand, Inclusive of Exports	122,752	.....	.....	.....	694,321	.....	.....	.....
(Daily Average)	4,092	.....	.....	.....	3,836	.....	.....	.....
MOTOR FUEL								
Production, Total	57,589	61,719	67,781	+ 10.0	328,914	356,110	400,710	+ 12.5
(Daily Average)	1,923	2,057	2,258	+ 9.8	1,812	1,957	2,214	+ 13.1
Imports	.....	.....	.....	.....	.....	.....	.....	.....
Change in Stocks	—2,635	—4,232	—3,036	.....	+4,999	+5,218	+1,865	.....
Stocks, Beginning of Period	91,281	78,955	82,775	+ 4.8	83,647	69,505	77,874	+ 12.0
Stocks, End of Period	88,646	74,723	79,739	+ 6.7	88,646	74,723	79,739	+ 6.7
(Days' Supply)	44	34	34	.0	50	38	36	— 5.3
Finished Gasoline	82,411	70,246	74,689	+ 6.3	82,411	70,246	74,689	+ 6.3
Natural Gasoline	6,235	4,477	5,050	+ 12.8	6,235	4,477	5,050	+ 12.8
Demand, Exclusive Small Imports	60,224	65,951	70,767	+ 7.3	323,015	350,892	402,575	+ 14.7
(Daily Average)	2,007	2,198	2,359	+ 7.3	1,785	1,972	2,224	+ 12.8
GASOLINE								
Production, (Straight Run, Cracked, Natural Blended)	55,136	59,898	65,677	+ 9.7	313,297	345,403	388,813	+ 12.6
(Daily Average)	1,838	1,996	2,189	+ 9.8	1,731	1,898	2,148	+ 13.2
Percent Yield, str. run, cracked	44.5	38.9	40.3	.....	43.7	38.8	44.8	.....
Imports	.....	.....	.....	.....	.....	.....	.....	.....
Change in Stocks, Finished	—3,014	—4,473	—3,086	.....	+4,468	+5,282	+1,067	.....
Stocks, Beginning of Period	85,425	74,519	77,775	+ 4.4	77,943	64,964	73,622	+ 13.3
Stocks, End of Period	82,411	70,246	74,689	+ 6.3	82,411	70,246	74,689	+ 6.3
(Days' Supply)	43	33	33	.0	48	38	35	— 7.9
Demand, Exclusive Small Imports	58,150	64,371	68,763	+ 6.8	308,829	340,121	387,746	+ 14.0
(Daily Average)	1,938	2,146	2,292	+ 6.8	1,706	1,869	2,142	+ 14.0
KEROSINE								
Production	5,218	6,246	6,561	+ 5.0	35,901	39,889	39,315	— 1.4
(Daily Average)	174	208	219	+ 5.3	198	219	217	— .9
Percent Yield from Crude	4.5	4.5	4.4	.....	5.4	4.9	4.5	.....
Imports	.....	.....	.....	.....	43	.....	.....	.....
Change in Stocks	+1,183	+1,708	+1,451	.....	+97	+466	—1,474	.....
Stocks, Beginning of Period	8,421	8,117	8,225	+ 1.3	9,512	9,359	11,150	+ 19.1
Stocks, End of Period	9,609	9,825	9,676	— 1.5	9,609	9,825	9,676	— 1.5
(Days' Supply)	72	65	48	— 26.2	49	45	43	— 4.4
Demand, Exclusive Small Imports	4,080	4,538	5,020	+ 10.6	35,804	39,423	40,789	+ 3.5
(Daily Average)	134	151	167	+ 10.6	198	217	225	+ 3.7
DISTILLATE FUEL OIL								
Production	14,697	20,023	21,496	+ 7.3	92,011	118,508	124,976	+ 5.5
(Daily Average)	490	668	717	+ 7.3	508	651	690	+ 6.0
Percent Yield from Crude	12.7	14.3	14.5	.....	13.8	14.6	14.4	.....
Transfers from Crude	210	253	250	— 1.2	1,220	1,600	1,567	— 2.1
Imports	211	.....	.....	.....	1,887	.....	.....	.....
Change in Stocks	+2,885	+1,753	+2,553	.....	—4,637	—7,486	—8,120	.....
Stocks, Beginning of Period	35,389	32,484	29,650	— 8.7	42,911	41,728	38,333	— 8.1
Stocks, End of Period	38,274	34,242	32,213	— 5.9	38,274	34,242	32,213	— 5.9
(Days' Supply)	95	56	51	— 8.9	71	49	44	— 10.2
Demand, Exclusive of Imports	12,022	18,270	18,933	+ 3.6	97,868	125,994	131,096	+ 4.0
(Daily Average)	401	609	631	+ 3.6	541	692	724	+ 4.6
Demand, Inclusive of Imports	12,233	.....	.....	.....	99,755	.....	.....	.....
RESIDUAL FUEL OIL								
Production	28,258	37,902	40,016	+ 5.6	165,753	227,959	239,416	+ 5.0
(Daily Average)	942	1,263	1,334	+ 5.6	916	1,253	1,323	+ 5.6
Percent Yield from Crude	24.4	27.1	27.1	.....	24.8	28.1	27.6	.....
Transfers from Crude	1,070	2,070	1,760	— 15.0	4,802	14,429	11,000	— 23.8
Imports	2,458	.....	.....	.....	17,021	.....	.....	.....
Change in Stocks	+730	+1,967	+2,048	.....	+8,078	—1,835	—14,835	.....
Stocks, Beginning of Period	79,218	44,682	33,500	— 25.0	88,026	48,484	50,383	+ 3.9
Stocks, End of Period	79,948	46,649	35,548	— 23.8	79,948	46,649	35,548	— 23.8
(Days' Supply)	84	39	28	— 28.2	81	37	25	— 32.4
Demand, Exclusive of Imports	28,586	35,935	37,968	+ 5.7	178,633	229,794	254,251	+ 10.6
(Daily Average)	953	1,198	1,266	+ 5.7	987	1,263	1,405	+ 11.2
Demand, Inclusive of Imports	31,053	.....	.....	.....	195,654	.....	.....	.....



considered that requirements were only around 1 billion barrels annually or 2,750,000 daily as recently as 1933 and 1934. There has been a doubling of demand in about 12 years.

In meeting this year's unprecedented demand, all sources of new supply have been called upon for more oils, including United States fields producing crude oil and those yielding natural gasoline and also foreign fields, while it has been necessary, additionally, to draw heavily on stocks, representing previously ac-

Stocks of Crude Petroleum in U. S. by Grades, at End of June

(Based on Weekly Reports of U. S. Bureau of Mines)

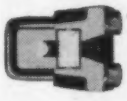
(THOUSANDS OF BARRELS)

Grade or Origin	June 28, 1941	July 1, 1944	June 30, 1945	Change 1941-1945
Pennsylvania Grade	4,297	2,651	2,114	— 2,183
Other Appalachian	1,420	1,506	1,304	— 116
Lima-Michigan	1,020	916	975	— 45
Illinois-Indiana	20,246	14,611	12,479	— 7,767
Arkansas	2,745	2,876	2,786	+ 41
Kansas	8,755	8,560	9,277	+ 522
Louisiana	12,439	13,241	13,915	+ 1,476
Northern	4,424	3,579	3,562	— 862
Gulf Coast	8,015	9,662	10,353	+ 2,338
Mississippi	1,507	873	1,256	— 251
New Mexico	7,203	6,411	5,953	— 1,250
Oklahoma	57,158	31,105	31,261	— 25,897
Texas	88,991	111,361	110,848	+ 21,857
East Texas	22,698	22,088	19,323	— 3,375
West Texas	16,557	29,946	31,687	+ 15,130
Gulf Texas	25,596	30,966	31,353	+ 5,757
Other Texas	24,140	28,361	28,485	+ 4,345
Panhandle	.....	6,287	4,924	.....
North	.....	5,895	7,581	.....
South	.....	6,317	7,381	.....
Other	.....	9,862	8,599	.....
Rocky Mountain	15,928	8,886	6,642	— 9,286
California	35,125	21,460	18,813	— 16,312
Foreign	2,565	1,967	3,158	+ 593
Total Gasoline Bearing in U.S.	259,399	226,424	220,781	— 38,618
Heavy in Calif.	10,716	5,945	4,940	— 5,776
Total U.S.	270,115	232,369	225,721	— 44,394

PENBERTHY
"REFLEX"
DROP FORGED STEEL LIQUID LEVEL GAGES

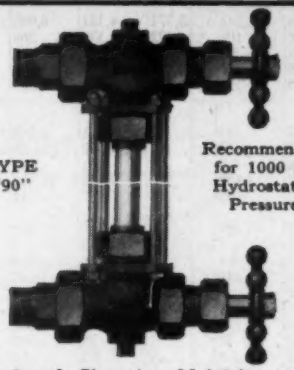
Liquid always shows black—empty space shows white. Preferred where the liquid level must be easily and positively visible, and when liquids are under high pressure or at high temperature. Made of alloy temperature resisting steel and are highest quality throughout. Liquid chamber made from solid block of steel to assure perfect alignment and rigidity. Conform with A.P.I.—A.S.M.E. requirements.

The "Reflex" is one of the complete line of Penberthy Gages that meet every liquid level gage requirement.



PENBERTHY INJECTOR CO.
DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

PENBERTHY
DROP FORGED STEEL LIQUID LEVEL GAGES



TYPE "90"

Recommended for 1000 lb Hydrostatic Pressure

Made of Chromium-Molybdenuin alloy temperature resisting steel, extra heavy throughout and stainless steel trimmed. Positive automatic shut-off; stainless steel balls shut off the flow of liquid if glass breaks. Regrinding removable seats, heavy duty stuffing boxes, union connections. Conform with A.P.I.—A.S.M.E. requirements.

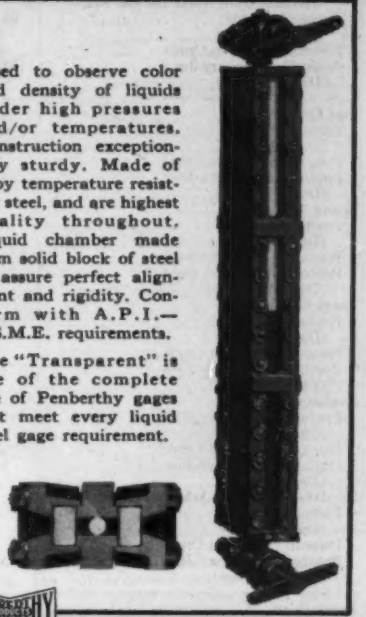
This is one of the complete line of Penberthy gages that meet every liquid level gage requirement.

PENBERTHY INJECTOR CO.
DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

PENBERTHY
"TRANSPARENT"
DROP FORGED STEEL LIQUID LEVEL GAGES

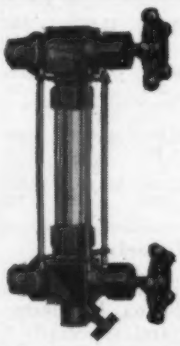
Used to observe color and density of liquids under high pressures and/or temperatures. Construction exceptionally sturdy. Made of alloy temperature resisting steel, and are highest quality throughout. Liquid chamber made from solid block of steel to assure perfect alignment and rigidity. Conform with A.P.I.—A.S.M.E. requirements.

The "Transparent" is one of the complete line of Penberthy gages that meet every liquid level gage requirement.



PENBERTHY INJECTOR CO.
DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

PENBERTHY
"ALL IRON"
LIQUID LEVEL GAGES

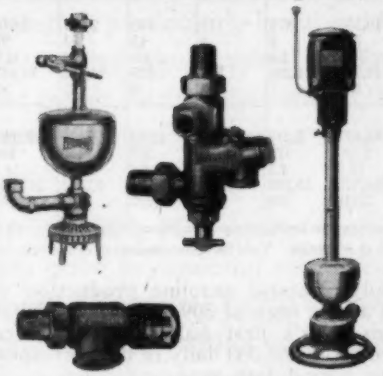


Body made from a special high strength alloy iron, shanks alloy steel and trim stainless steel. Extra heavy construction throughout, automatic and positive shut-off if glass breaks, heavy duty stuffing boxes. Conform with A.P.I.—A.S.M.E. requirements.

The "All Iron" is one of the complete line of Penberthy gages that meet every liquid level gage requirement.

PENBERTHY INJECTOR CO.
DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

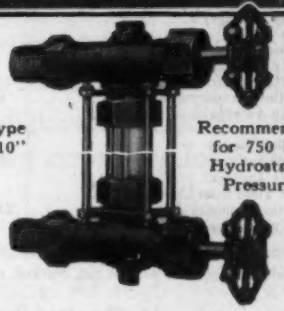
PENBERTHY
QUALITY PRODUCTS



Penberthy injectors—ejectors—automatic electric and water (or steam) operated sump pumps are all widely used throughout the oil industry because they have always been dependable under the most severe service conditions.
All are of rugged construction and made by an organization with 59 years experience in the manufacture of highest quality products.

PENBERTHY INJECTOR CO.
DETROIT 2, MICH. Canadian Plant WINDSOR, ONTARIO

PENBERTHY
DROP FORGED STEEL LIQUID LEVEL GAGES



Type "10"

Recommended for 750 lb. Hydrostatic Pressure

Steel construction throughout with stainless steel interior trim. Automatic shut-off is positive and instantaneous; stainless steel balls shut off the flow of liquid when glass breaks. Heavy duty stuffing boxes, union connections, offset construction facilitate cleaning and simplify glass replacement. Conform with A.P.I.—A.S.M.E. requirements.

This is one of the complete line of Penberthy gages that meet every liquid level gage requirement.

PENBERTHY INJECTOR CO.
DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

Refinery Production of Major Products and Percent Yield from Crude Run by Districts

Results in June and first 6 months, 1945, compared with those in like period last year and in 1941, last pre-war year for U. S. All data from U.S. Bureau of Mines except May and June, 1945, estimated with aid of A.P.I. weekly bulletins.

(THOUSANDS OF BARRELS)

DISTRICTS	*GASOLINE			KEROSINE			DISTILLATE FUEL OIL			RESIDUAL FUEL			LUBRICANTS		
	1941	1944	1945	1941	1944	1945	1941	1944	1945	1941	1944	1945	1941	1944	1945
Combined East Coast, Texas Inland, Texas Gulf, La. Gulf, North La. and Ark.															
Production, June	26,495	30,193	33,196	3,245	3,971	4,134	8,066	11,925	12,749	13,735	18,523	18,170	1,888	1,943	2,033
(Daily Average)	883	1,006	1,106	108	132	138	269	398	425	458	617	606	63	65	67
Percent Yield from Crude	43.5	37.1	39.3	5.6	5.4	5.4	14.0	16.3	16.7	23.9	25.3	23.8	3.3	2.7	2.7
Production, January-June	153,678	168,733	196,305	22,866	24,873	25,028	54,301	71,813	74,755	81,697	109,418	111,116	9,630	10,864	11,561
(Daily Average)	849	927	1,085	126	137	138	300	394	413	451	601	614	53	60	64
East Coast															
Production, June	6,871	.....	7,693	548	.....	701	2,680	.....	4,402	4,465	.....	6,786	769	.....	792
(Daily Average)	229	.....	256	18	.....	23	89	.....	147	149	.....	226	26	.....	26
Percent Yield from Crude	39.9	.....	33.4	3.2	.....	3.1	15.8	.....	19.6	26.3	.....	30.3	4.5	.....	3.4
Production, January-June	39,591	.....	48,265	4,162	.....	4,819	20,337	.....	24,369	25,471	.....	41,513	3,900	.....	4,257
(Daily Average)	219	.....	267	23	.....	27	112	.....	135	141	.....	229	22	.....	24
Inland Texas															
Production, June	3,623	.....	4,119	227	.....	359	168	.....	540	1,206	.....	1,994	25	.....	22
(Daily Average)	121	.....	137	7	.....	12	6	.....	18	40	.....	66	1	.....	1
Percent Yield from Crude	54.5	.....	46.1	4.1	.....	5.0	3.0	.....	7.5	21.7	.....	27.7	.5	.....	.3
Production, January-June	20,684	.....	24,616	1,546	.....	2,354	1,149	.....	3,144	6,972	.....	11,951	191	.....	127
(Daily Average)	114	.....	136	9	.....	13	7	.....	17	38	.....	66	1	.....	1
Texas Gulf															
Production, June	13,386	.....	16,556	1,732	.....	1,823	4,206	.....	6,062	6,610	.....	7,460	850	.....	932
(Daily Average)	446	.....	552	58	.....	61	140	.....	202	220	.....	249	28	.....	31
Percent Yield from Crude	44.5	.....	41.3	6.1	.....	5.1	14.8	.....	16.9	23.2	.....	20.8	3.0	.....	2.4
Production, January-June	77,942	.....	96,212	12,218	.....	10,827	27,698	.....	37,486	39,821	.....	46,012	4,259	.....	5,358
(Daily Average)	431	.....	531	67	.....	60	153	.....	207	220	.....	254	23	.....	30
Louisiana Gulf															
Production, June	1,734	.....	3,799	530	.....	1,016	834	.....	1,428	1,004	.....	1,376	187	.....	188
(Daily Average)	58	.....	127	18	.....	34	28	.....	47	34	.....	46	6	.....	6
Percent Yield from Crude	38.5	.....	43.3	11.9	.....	12.4	18.8	.....	17.4	22.6	.....	16.8	4.2	.....	2.2
Production, January-June	9,601	.....	21,394	3,412	.....	5,684	4,043	.....	8,027	6,103	.....	8,342	926	.....	1,097
(Daily Average)	53	.....	118	19	.....	31	22	.....	44	34	.....	46	5	.....	6
North Louisiana and Arkansas															
Production, June	881	.....	1,029	208	.....	235	181	.....	317	450	.....	554	57	.....	129
(Daily Average)	29	.....	34	7	.....	8	6	.....	11	15	.....	19	2	.....	4
Percent Yield from Crude	40.1	.....	32.1	9.8	.....	9.1	8.5	.....	12.3	21.2	.....	21.5	2.6	.....	3.0
Production, January-June	5,860	.....	5,818	1,528	.....	1,344	1,074	.....	1,729	3,330	.....	3,298	354	.....	712
(Daily Average)	32	.....	32	8	.....	7	6	.....	10	18	.....	18	2	.....	4
Appalachian															
Production, June	2,147	1,893	2,120	242	319	283	422	464	551	658	677	852	565	435	430
(Daily Average)	72	63	71	8	11	9	14	15	18	22	23	28	19	14	14
Percent Yield from Crude	47.2	41.6	43.9	5.4	7.1	6.0	9.4	10.4	11.6	14.7	15.1	17.9	12.6	9.7	8.9
Production, January-June	12,313	11,773	12,808	1,655	2,004	1,823	2,431	3,162	3,243	3,909	4,612	5,071	3,064	2,641	2,496
(Daily Average)	68	65	71	9	11	10	13	17	18	22	25	28	17	14	14
Illinois, Indiana, Kentucky															
Production, June	11,728	11,706	11,702	701	1,145	957	2,371	2,685	2,955	3,883	4,809	4,258	347	329	336
(Daily Average)	391	390	390	24	38	32	79	90	98	130	160	142	12	11	11
Percent Yield from Crude	52.7	47.6	48.1	3.3	4.9	4.2	11.2	11.6	13.0	18.3	20.7	18.7	1.6	1.4	1.7
Production, January-June	64,250	69,120	72,837	5,832	6,814	5,912	12,466	17,401	18,047	23,164	28,536	27,136	1,930	2,313	2,386
(Daily Average)	355	380	402	32	38	33	69	96	100	128	157	150	11	13	13
Oklahoma, Kansas, Missouri															
Production, June	5,817	5,642	6,246	672	633	722	1,077	1,652	2,001	1,824	1,911	2,021	347	362	470
(Daily Average)	194	188	208	22	21	24	36	55	67	61	64	67	11	12	16
Percent Yield from Crude	50.9	47.6	50.0	6.2	5.7	6.1	10.0	14.9	17.0	16.8	17.3	17.2	3.2	3.3	4.0
Production, January-June	33,344	32,600	36,277	3,860	4,248	4,429	6,516	9,046	10,947	10,718	11,498	12,534	1,884	2,202	2,739
(Daily Average)	184	179	200	21	23	24	36	50	61	59	63	69	10	12	15
Rocky Mountain															
Production, June	1,365	1,732	1,857	82	67	95	231	384	442	582	797	1,102	9	29	26
(Daily Average)	45	58	62	3	2	3	8	13	15	19	26	37	.3	1	1
Percent Yield from Crude	45.0	46.7	43.0	2.8	1.9	2.4	7.9	11.0	11.0	19.9	22.8	27.4	.3	.8	.5
Production, January-June	8,446	9,377	10,834	433	437	596	1,336	2,199	2,440	3,550	5,446	6,494	96	141	134
(Daily Average)	47	51	60	3	2	3	7	12	14	20	30	36	.5	1	1
California															
Production, June	7,584	8,732	10,556	276	111	370	2,527	2,918	2,798	7,573	11,185	13,613	364	355	389
(Daily Average)	253	291	352	9	4	12	84	97	93	252	373	454	12	12	13
Percent Yield from Crude	34.2	30.8	31.7	1.5	.5	1.3	13.4	11.9	9.9	40.1	45.6	47.9	1.9	1.4	1.3
Production, January-June	41,266	53,800	59,752	1,255	1,513	1,527	14,961	14,887	15,544	42,715	68,449	77,065	1,729	1,927	2,086
(Daily Average)	228	296	330	7	8	8	83	82	86	236	376	426	10	10	12
Total, United States															
Production, June	55,136	59,898	65,677	5,218	6,246	6,561	14,697	20,028	21,496	28,255	37,902	40,016	3,520	3,453	3,714
(Daily Average)	1,838	1,996	2,189	174	208	219	490	668	717	942	1,263	1,334	117	115	124
Percent Yield from Crude	44.5	38.9	40.3	4.5	4.5	4.4	12.7	14.3	14.5	24.4	27.1	27.1	3.0	2.5	2.5
Production, January-June	313,297	345,403	388,813	35,901	39,889	39,315	92,011	118,508	124,976	165,753	227,959	239,416	18,333	20,088	21,393
(Daily Average)	1,731	1,898	2,148	198	219	217	508	651	690	916	1,252	1,323	101	110	118

* Production includes straight run, cracked, and natural blended at refineries. Yield incidates precent of crude runs made into straight run and cracked gasoline.

cumulated oils. At the middle of the year stocks of all oils totaled about 452,000,000 barrels, lowest level since 1923 and down 25,000,000 barrels from the beginning of this year.

Domestic production of all oils averaged 5,125,000 barrels daily in the first half of this year, an increase of 8.1 percent over the 4,739,000 daily in the like period last year. In the initial half of 1941, last prewar year for the United States, domestic output averaged only 3,896,000 barrels daily. The increase for natural gasoline was sharper than that for crued oil. The domestic production of crude averaged 4,808,000 barrels daily, an increase of 7:5 percent over the 4,470,000 per day for the first half of last year. In January-June 1941 output averaged only 3,680,000 barrels daily. Natural gasoline production was at a new high of 309,000 barrels daily in this year's first half, up 17.9 percent from the 262,000 daily in the corresponding period last year.

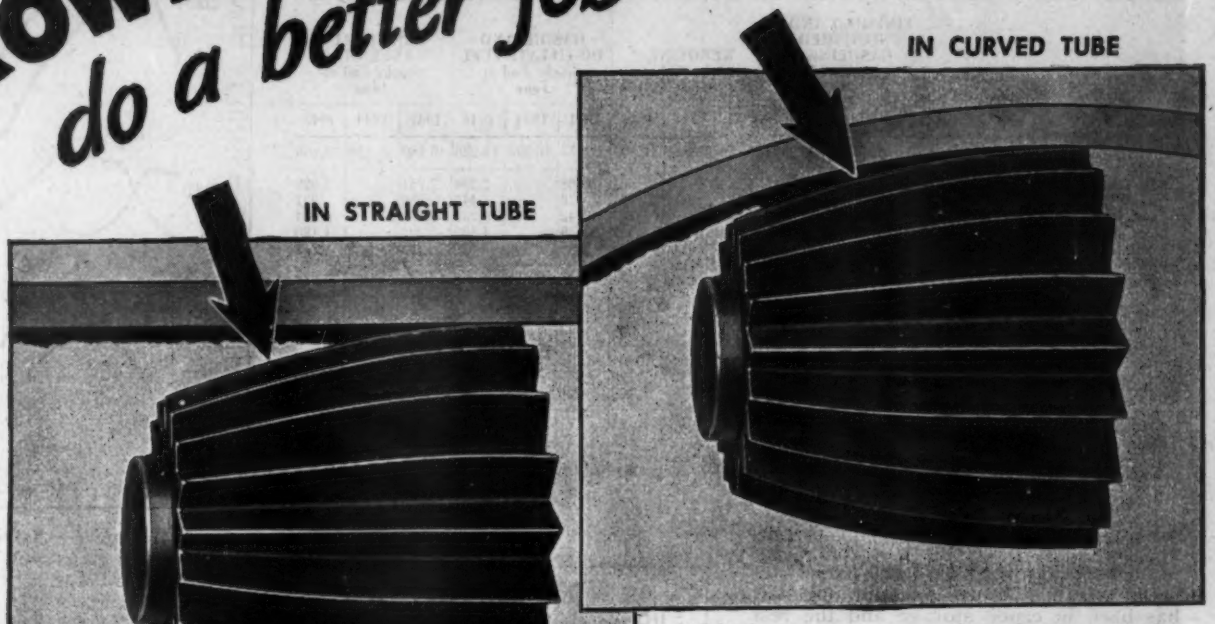
District Production

Although the United States as a whole produced 7 percent more crude in the first half of this year than in the like period last year, there were declines in nearly half the districts to hold down the national increase. States and districts that declined included Arkansas, Florida, Illinois, Indiana, Kansas, North Louisiana, Michigan, Montana, Nebraska, New Mexico, New York, Ohio, Pennsylvania, the Texas Panhandle, and West Virginia. Those declines were more than offset by increases in Alabama, California, Colorado, Kentucky, South Louisiana, Mississippi, Oklahoma, Wyoming, and especially Texas, where all districts except the Panhandle registered gains. California's production was up nearly 10 percent, as was that of Texas, but gains for Louisiana and Oklahoma were only about 1 percent. Among the Texas districts the greatest increase was in West Texas, although the Southwest Texas districts also showed exceptional increases.

Low Stocks

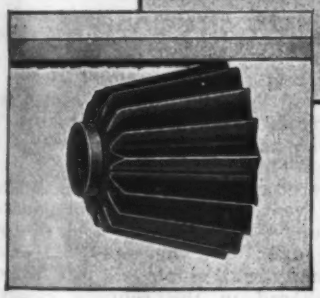
On declining to about 452,000,000 barrels at midyear 1945, the stocks of all oils were about 20,000,000 barrels lower than at the middle of 1944, but with demand running higher, they represented only 86 days' supply against 98 days' a year

CROWN CUTTERS *do a better job*



At left, the new type cutter in a straight tube. The curved edge of the cutter permits more of its surface to contact the tube and avoids point contact.

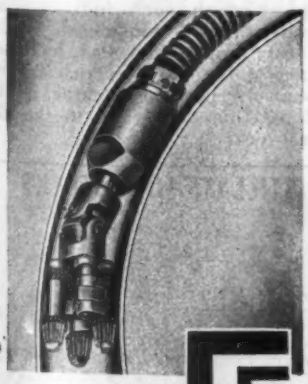
Above, the crown cutter in a curved tube naturally and easily conforms to the contour of the tube. More cutting surface is made usable on a crown cutter.



WITH FORMER DESIGN the sharp edge at the rear of the cutter was the only part to meet the tube wall.

Improved cutter design for
ELLIOTT *Lagonda Type* TUBE CLEANERS

Rounding the teeth of front cutters removes all possibility of sharp corners scoring tubes, particularly in curved tubes. This cutter is now standard in all Elliott cutter heads using a 1 in. or larger cutter. Except for the rounded center section, the cutter is the same in dimension as the straight sided cutter formerly used, and will be supplied on orders for cutter replacements.



"TRACKLESS", TOO—cutter teeth are so spaced as to avoid striking the same point in repeated rotation inside the tube. At each revolution a tooth attacks a point slightly in advance of the former point, removing all deposit and preventing gear design in the tube. Another safeguard protecting tube inner surfaces.

For up-to-the-minute developments in tube cleaning, come to Tube Cleaning Headquarters. Elliott Tube Cleaner Bulletin on request.

ELLIOTT *Company*

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Plants at: JEANNETTE, PA. • RIDGWAY, PA.
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DISTRICT OFFICES IN PRINCIPAL CITIES

Y-249

Stocks of Major Petroleum Products Held by Refining Companies in the United States at End of June, 1941, 1944 and 1945

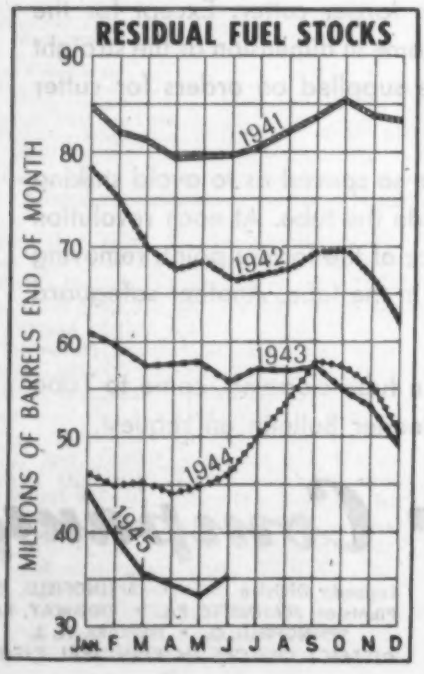
Stocks at refineries, at bulk terminals, in transit, and in pipe lines. Data for 1941 and 1944 from Bureau of Mines monthly reports; for 1945 from weekly reports of American Petroleum Institute.

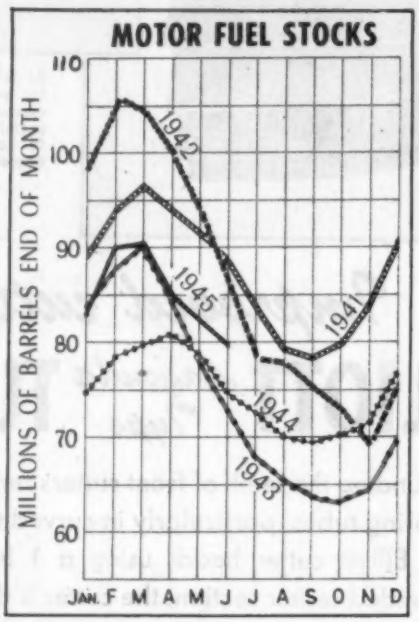
(THOUSANDS OF BARRELS)

DISTRICT	FINISHED AND UNFINISHED GASOLINE Stocks End of June			KEROSINE Stocks End of June			GASOIL AND DISTILLATE FUEL Stocks End of June			RESIDUAL FUEL OIL Stocks End of June		
	1941	1944	1945	1941	1944	1945	1941	1944	1945	1941	1944	1945
Combined East Coast—Southwest	43,076	35,798	36,345	6,426	6,364	6,406	21,673	18,896	16,236	19,180	15,488	14,166
East Coast	22,698	.....	13,181	1,304	.....	3,373	10,868	.....	7,286	7,761	.....	5,929
Inland Texas	2,809	.....	2,908	231	.....	244	279	.....	445	1,566	.....	921
Texas Gulf Coast	13,508	.....	13,647	3,768	.....	1,537	8,742	.....	6,032	8,171	.....	6,024
Louisiana Gulf Coast	3,351	.....	3,985	881	.....	1,067	1,539	.....	1,803	1,294	.....	1,120
North Louisiana and Arkansas	710	.....	2,624	242	.....	185	245	.....	670	388	.....	172
Appalachian	3,292	3,353	4,363	166	384	314	376	1,384	442	539	499	331
District No. 1	.....	.....	3,017	.....	.....	250	.....	.....	346	.....	.....	264
District No. 2	.....	.....	1,346	.....	.....	64	.....	.....	96	.....	.....	67
Indiana, Illinois, Kentucky	17,786	18,477	19,939	1,212	1,926	1,604	3,774	5,229	4,415	3,568	3,488	2,280
Oklahoma, Kansas, Missouri	7,595	7,000	7,555	560	606	795	1,397	1,372	1,818	2,066	1,399	1,245
Rocky Mountain	2,036	2,191	2,456	103	85	128	296	358	343	640	630	565
District No. 3	.....	.....	86	.....	.....	20	.....	.....	21	.....	.....	36
District No. 4	.....	.....	2,370	.....	.....	108	.....	.....	322	.....	.....	529
California	16,057	15,165	13,914	1,142	460	429	10,853	8,003	8,959	55,024	25,145	16,961
Total United States	89,842	81,984	81,984	9,609	9,825	9,676	38,369	35,242	32,213	81,017	46,649	35,548

previously. Of the 20,000,000-barrel decrease since a year ago about one half has been in crude storage and the rest in refined products. Crude stocks stood at 220,781,000 barrels June 30, 1945, compared with 229,631,000 a year before and 259,695,000 barrels at the end of June, 1941. Heavy crude in storage in California totaled 4,940,000 barrels against 6,118,000 a year before and 10,711,000 in 1941. Stocks of refined products amounted to 221,709,000 against 232,767,000 a year previously and 275,229,000 in June, 1941.

The stocks of each of the major products are at exceptionally low levels. Gas-withdrawals have been largely in Caliofine inventories are several million barrels above a year ago, but the gain has been only in military grades, and the total is about 9,000,000 barrels lower than at this time in 1941. Kerosine stocks are about the same as a year ago about 3,000,000 barrels higher than at



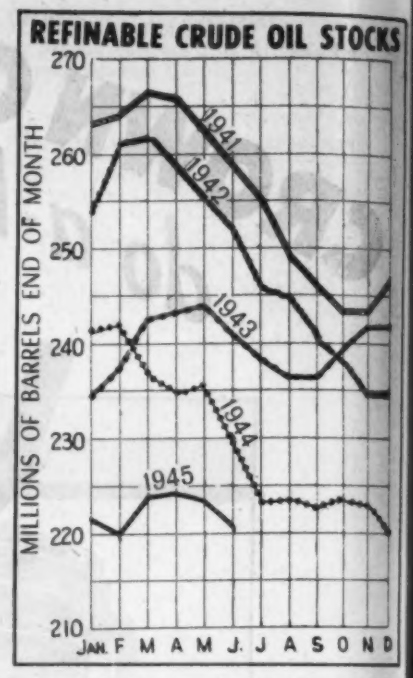


mid-1941. Distillate fuel oil inventories are 2,000,000 barrels lower than a year ago and 6,000,000 lower than at this time in 1941, although demand is much greater. Residual fuel oil has been especially instrumental in the declines in stocks of refined products, present inventories being 11,000,000 barrels lower than a year ago and 44,000,000 barrels lower than at the middle of 1941.

Runs to Stills Up

Crude oil runs to stills have shown increases closely in line with those for crude production. In the first half of this year the refinery runs averaged 4,785,000 barrels daily, up 7.5 percent from the 4,450,000 daily in the like period last year, and comparing with only 3,694,000 daily for January-June, 1941. Plants processed about 30,000,000 barrels of foreign crude against 18,626,000 in last year's first half, in reflection of increased imports.

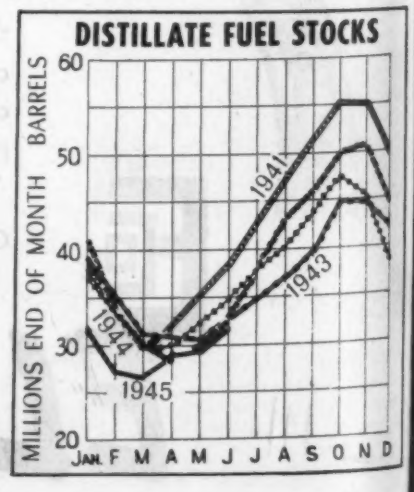
California plants processed 10 percent more crude in this year's first half than in last year's and those of the



Rocky Mountain district 15 percent more, while gains for other refining districts included 8 percent for Oklahoma-Kansas-Missouri, 7 percent for the combined East Coast-Southwestern districts, less than 5 percent for the Appalachian region, and a little over 2 percent for Illinois-Indiana-Kentucky.

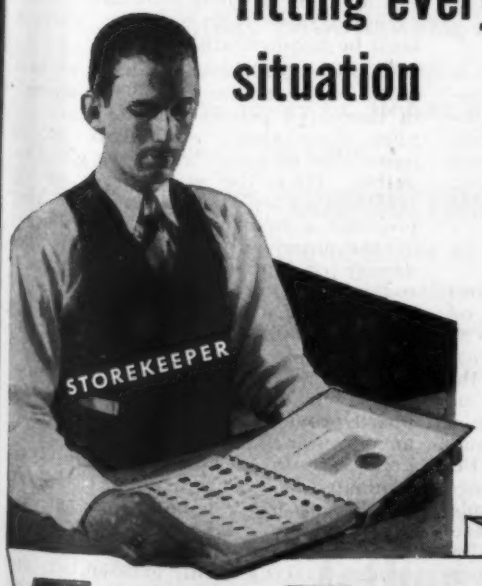
The nation's refining capacity in June, 1945 was 5,432,000 barrels of crude daily and that was utilized to the extent of 90.7 percent. A year previously the capacity had been built up only to 4,908,000 barrels daily, which was used by the abnormally high proportion of 95 percent. Thus more than 500,000 barrels per day of capacity has been completed since a year ago. The present potential is about 900,000 barrels a day above that in June, 1941, when only 85.2 percent of capacity was employed. All districts have shared in the refinery capacity expansion, and increases in production of all products for all districts have been the rule.

The continued over-all increase in demand for petroleum this year has been due to further gains for practically all products, although such individual increases have varied considerably. The demand for motor fuel has increased most sharply, the daily average having been about 13 percent greater in the first half of this year than in the like period last year.



Welding Fittings Information

fitting every situation



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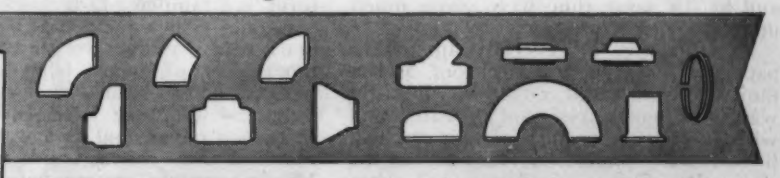

THE COMPLETE LINE OF WELDING FITTINGS AND FLANGES

Processing Materials From Petroleum

JOHN C. DEAN
Technical Division, Process Products,
Socony-Vacuum Oil Company

Petroleum has many uses as a fuel, lubricant, and raw material for synthetic organic chemicals. This article however, is not concerned with these petroleum products, although some organic chemists would probably be delighted with pages covered with chemical symbols and reactions. Some other chemists might be bored, but for them let us say just one thing, which is that the oil companies are already in the chemical business. They make hundreds of pure synthetic chemicals, among them butadiene and styrene for synthetic rubber, toluene for TNT, and iso-octane for aviation gasoline. But we have heard and read much of these during the past few years. Here we get some idea of another important group of petroleum products which are widely used in industry as processing materials.

THIS article is a discussion of a little known phase of the oil business—the use of petroleum as a processing material. If one looks about, he will be able to find very few articles which do not utilize a petroleum product somewhere in manufacture. The clothes and shoes one wears, the furniture one sits on, the paper one sees, and a host of other everyday articles either contain petroleum, or used it while being made. It has never been determined accurately how much petroleum is so employed, but it is known that the quantities run into millions of barrels per year.

The scope of petroleum's utility as a processing material is virtually unlimited. At present over 30 basic industries employ petroleum in their manufacturing processes, and the individual applications are numbered in the thousands. Obviously it is possible to give but a bird's-eye view of the subject in so short a time, and for that reason, only the more important products and their most interesting uses can be covered. These will be discussed as groups rather than as specific materials, since the fundamental properties of the individual members are characteristic of the entire group.

Paraffin Wax

Everyone has seen paraffin wax and most of us know that it is of petroleum origin. How many, however, realize that over 700,000,000 pounds of paraffin wax are produced each year in this country alone? How many are aware that it is removed from light spindle oils so that these oils will flow at low temperatures?

To be sure, some small portion of that 700,000,000 pounds is used for preserving, and a much larger portion goes into candles, but about 80 percent of it is employed by industry for use on paper and paper products. Many of these products are so commonplace that we often fail to realize that they do use paraffin wax. There are bread wrappers, paper milk bottles, paper drinking cups, butter cartons, cracker boxes, and drinking straws. Also, there are many other commercial paper products requiring paraffin wax which are seldom seen. It is of interest that most of our 500 and 1000-pound bombs, which were dropping regularly on the Germans and are now dropping on the Japs, rolled on paper bomb rings impregnated with paraffin wax as the bombs were trundled to the planes into which they were loaded. These paper bomb rings replaced those formerly made of metal at considerable saving in steel and cost, and at the same time have given much improved performance.

Paraffin wax is generally applied to paper to provide a waterproof and a moisture-vaporproof coating. Paraffin wax is extremely resistant to water, and when a continuous film of it is applied, it forms an impervious barrier on the paper. Paraffin wax is cheap, easily handled, chemically inert, and almost completely nontoxic. These properties, together with its low cost and ready availability, make it doubtful that it will be supplanted as the most extensively used paper coating material.

Paraffin wax has other uses far too numerous to list entirely. One of the more interesting ones is the manufacture of fuel tablets which soldiers in the front lines use to heat coffee and soup. These little boxes of wax can be lighted easily and will burn in the heaviest of winds. Paraffin wax is used also to make artificial fruit and other wax articles, and is even employed as a window paning for chicken coops. Since it transmits more ultraviolet light than does glass, the chickens in the coop will lay more and better eggs.

Paraffin wax has a big brother known as microcrystalline wax which has become a valuable war material. This wax was at one time an ugly duckling of the petroleum industry, and like this fabled fowl, has grown from something little wanted to an extremely desirable and valuable product.

Microcrystalline Waxes

Microcrystalline waxes were first made in 1926 when it was found that oil could be removed from petrolatum to produce a hard, tough, and flexible material. Petrolatum was formerly the bane of early refiners of lubricating oil who went to great pains to remove it from the oil so that their lubricants would flow at low temperatures. Petrolatum, at least in its highly refined form, is a familiar product. For example, Vaseline—which incidentally is a trademark of a manufacturer and not a commodity—is produced from crude petrolatum. Petrolatum is also used in butchers' wrapping paper, in cosmetics, in carbon paper, and as a waterproofing material for canvas and rock wool. While formerly unused petrolatum was burned as a fuel, the situation is different today. Petrolatum is now the source of the very valuable microcrystalline waxes.

When these waxes were first made, they appeared to be noncrystalline in nature and were therefore called amorphus waxes. However, it was soon found that they contained small-sized crystals, and for that reason they are known today by the more correct term "microcrystalline waxes." For those who are not familiar with these waxes, they can be described most simply as resembling beeswax. In some of the early efforts to market them they were actually designated as "mineral beeswax."

One of the first uses of the microcrystalline waxes was the coating and impregnating of such electrical parts as capacitors, coils, and wires. The waxes are highly waterproof, and are so tough and flexible that they can withstand exposure to low temperatures without fracture. They thus prevent water from entering the critical portions of the electrical apparatus and impairing its performance.

Other uses for microcrystalline waxes were soon found. It was discovered that they had great utility as paper coatings, particularly when blended with paraffin wax. As stated above, the purpose of coating paper with paraffin is to provide a continuous barrier against the passage of moisture, but one small break in the wax film destroys the barrier just as does a puncture in an automobile tire. The incorporation of microcrystalline wax into paraffin wax reduces the tendency of the paraffin to fracture when flexed or handled roughly at low temperatures. Its uses in packaging dehydrated foods where moisture must be excluded, and frozen foods, where it must be retained, are obvious.

Microcrystalline waxes have an even more important use in the manufacture of laminated papers. As the name implies, these sheets consists of two or more plies of paper which are glued together. Here the wax serves as the bonding agent, and at the same time provides a moisture-vaporproof barrier at the interior of the sheet. A wide variety of laminated papers are made today by a combination of different base papers so that advantage can be taken of the peculiar properties of each paper. For example, a cracker box might be made of a paperboard to which glassine paper has been laminated. The paperboard provides rigidity, the wax, resistance to moisture-vapor, and the glassine, grease-proofness. Other frequently-seen laminated papers are made of two sheets of glassine paper bonded together, and are used for packaging potato chips, pretzels, peanuts, and many dehydrated foods. A transparent, greaseproof, and moistureproof package is thus obtained.

Microcrystalline waxes are extremely versatile, and can be used for hundreds of different purposes. Metal containers all types have been lined with them to protect the metal against the corrosive

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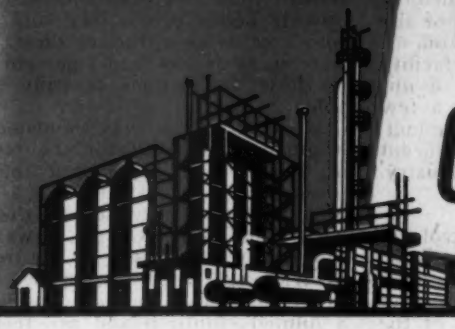

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action of the contents. Beer, wine, vinegar, and many dilute acids have been shipped in cans, barrels, and tank cars so treated with these waxes.

Microcrystalline waxes are used in high grade inks to prevent "skinning," and are ingredients of carbon paper, rubber, crayons, and a host of wax compositions. They have replaced ozokerite, formerly imported from Germany, as a molding wax in the electrotyping process. Since they are also resistant to the action of hydrofluoric acid, they are used to make bottles for shipping it, and employed as a protective film in etching glass.

Packaging for War

Many of the above uses have been discontinued today because the petroleum industry is unable to supply microcrystalline waxes for both military and civilian needs. The microcrystalline waxes have literally gone to war.

While our armed forces probably did not know it at the beginning of the war, they soon discovered that they did not have an entirely satisfactory method of packaging. This was particularly true where spare metal parts, precision instruments, foodstuffs, and the like were exposed to water for long periods of time. The African invasion of 1942 showed very quickly that some new method of packaging was needed if we were to prevent the loss of large amounts of materiel in amphibious and offshore unloadings. Since metal was critically scarce, and cannisters and other metal containers could not be employed widely, some new package was needed.

The Ordnance Department worked with dispatch and efficiency, and with the cooperation of users and producers of microcrystalline wax it developed the method of packaging that is being employed today for countless quantities of vital metal articles. In it the metal pieces are first protected with an oily and easily removed rust preventive that gives immediate protection to the surface. They are then covered with a greaseproof paper of paper bag which holds the rust preventive on the surface of the metal. In the next step, the pieces are wrapped in a special paper, now known as "Grade C" paper, which is heavily coated with microcrystalline wax. This paper is extremely flexible and can be made to conform to the shape of the piece without fracture of the wax film. It also is so adhesive that two layers of it will stick together and produce what is nearly a continous covering. The wrapped parts may then be placed in paperboard boxes and dipped in a bath of liquid microcrystalline wax, or they may be dipped directly to coat the exteriors with heavy wax films. Large numbers of the wrapped parts are finally placed in a suitable carton or box, ready for overseas shipment. This method is so effective that metal can be stored under salt water for a long time with no danger of rusting.

Shortly before the Ordnance Department announced this need for large quantities of microcrystalline wax it had also developed a new package for small arms ammunition. Here the soldered metal box used in World War I was replaced with a heavily-waxed paperboard carton, at a considerable saving in weight and cost. At the same time the Quartermaster Corps developed a method of packaging field rations which required dipping the packages in a bath of a molten blend of paraffin and microcrystalline wax.

The inevitable result of this activity in packaging was a tremendous demand for microcrystalline waxes. The total production of these materials in in 1942 was little more than twenty million pounds per year, but in 1943 it was immediately evident that six or seven times this quantity was needed for essential uses alone. As a result of the efforts of the PAW and of the oil industry in general, every available facility was utilized for the production of microcrystalline waxes, and in but a few months the essential demands were met. This has been another magnificent achievement of the petroleum industry.

Wax Emulsions

Most of the above uses for petroleum waxes have been as "hot melt coatings" —that is, wax is applied in a molten condition. There are, however, other methods of applying waxes, one of the most effective of which is in the form of an emulsion. These "wax emulsions" are suspensions of wax in water stabilized with suitable emulsifiers and dispersing agents. Wax emulsions look like milk, and in fact are quite similar in general composition to milk, which is essentially a suspension of butter fat in water stabilized with casein. The wax particles of an emulsion are similar to the droplets of butter fat, and the emulsifiers are comparable in action to the casein.

One of the advantages of a wax emulsion is that it permits small quantities of wax to be applied in controlled amounts. This is also possible with solutions of wax, but for a number of reasons emulsions have largely replaced such solutions. No costly solvent recovery units are needed, the vehicle (water) is nontoxic and noninflammable, and the application can be effective at very low cost and with readily available equipment.

One of the most important uses of a wax emulsion is the treatment of textiles to impart a water-repellent finish. This is accomplished by running the textile cloth through a bath of wax emulsion in which it picks up some of the emulsion. Upon drying, small amounts of wax (generally between 1 and 4 percent become deposited on the individual fibers and render them resistant to water. The cloth then has watershed properties. This treatment has practically no effect upon the appearance of the cloth or upon its feel or "hand." Furthermore, because of the openings which remain between the fibers, adequate ventilation results when the textile is used for clothing. If the fabric were waterproofed by a hot melt coating, it would be stiff and board-like, and entirely unsuitable as a clothing material. The armed forces have purchased millions of yards of such fabrics as tent cloth, drills, cotton duck, and mosquito netting, all of which have been given this water-repellent treatment.

A second extremely important use of wax emulsions is in the manufacture of paper, where once again small quantities of wax are capable of imparting water-resistance. There are two methods of introducing the wax into paper, one prior to the formation of the sheet, and the other as a treatment of finished paper. The former method is known as beater-sizing, and involves adding wax emulsion to the pulp while it is being beaten. By this method the microscopic wax particles of the emulsion are deposited uniformly on the paper fibers and give each fiber a degree of water-repellency.

The second method of treatment is known as surface-sizing, or top-sizing, and is accomplished by passing a finished sheet of paper through a bath of emulsion in substantially the same manner as in the treatment of textiles. Wax emulsions improve the water-resistance of paper, enhance resistance to scuffing, provide better printability, and yield a smoother, more attractive sheet. The effectiveness of less than 1 percent of wax in these applications is truly remarkable.

Most petroleum wax emulsions were originally developed for the treatment of textiles and paper, but they have proved to be so versatile that a number of other interesting uses for them have been found. For example, a wax emulsion is now being used for the treatment of white potatoes to improve storing properties. Clean potatoes are dipped in a diluted emulsion and are then dried to deposit small amounts of wax on their surfaces. In actual practice one gallon of emulsion will treat between 30 and 40 bushels of potatoes, which will then remain fresher, last longer, and show much less loss in weight during storage. In addition, wax emulsions have been found to be effective for the treatment of cut potato seed before it is planted. Here it prevents rotting of the seed during wet weather and ensures a healthier stand of potato plants after germination and sprouting, so that increases in yield up to 15 percent have been reported in many instances.

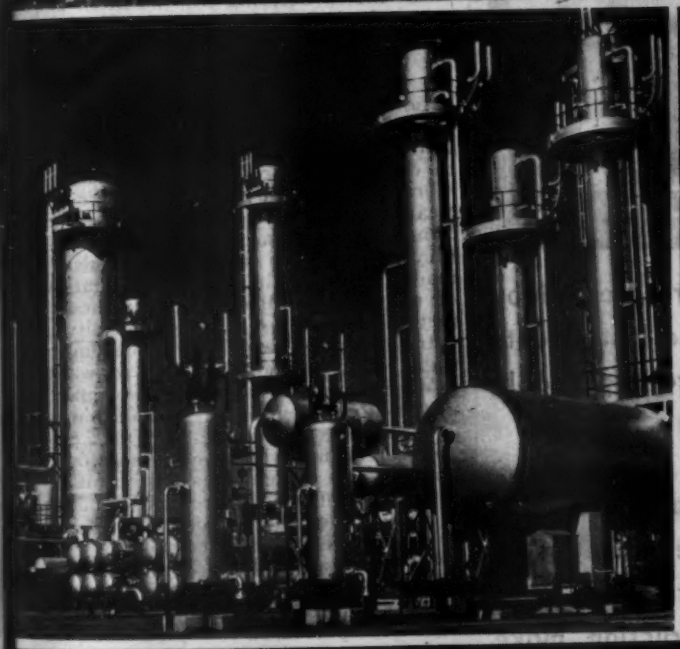
The manufacture of certain wooden articles, such as bowling pins and shoe lasts, can be facilitated by a wax emulsion treatment of rough-cut blocks which are kiln-dried before being turned down to finished articles. These blocks are generally cut from green lumber, which, if allowed to dry with no treatment, would develop cracks or checks that penetrate well into the wood. This splitting is caused by stresses and strains that are set up in the blocks because of nonuniform loss of moisture. The thin film of wax which is deposited ensures uniform drying and practically eliminates the destructive internal stresses.

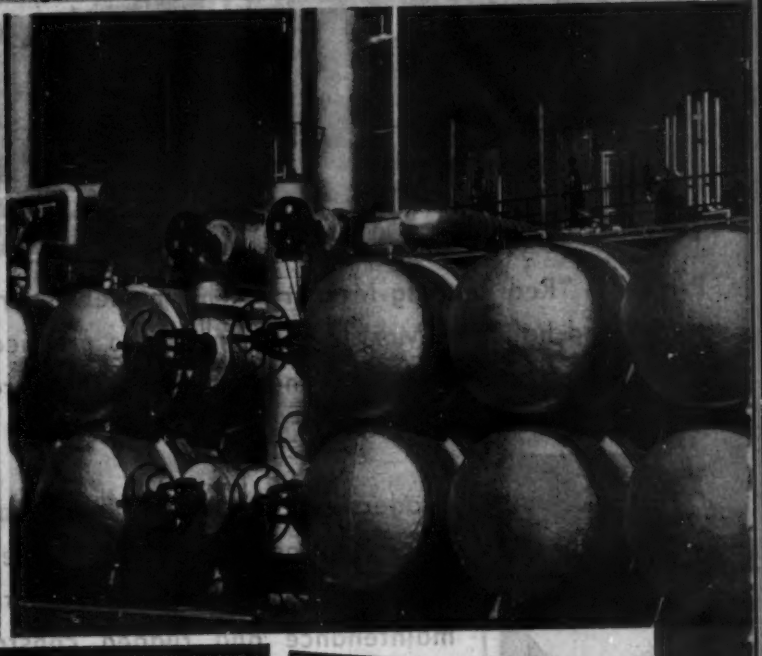
Certain wax emulsions have been used for waterproofing the exterior of buildings which have begun to leak during rainy weather. The microscopic cracks and holes become filled wtih wax particles so that even highly porous walls can be rendered waterpoor.

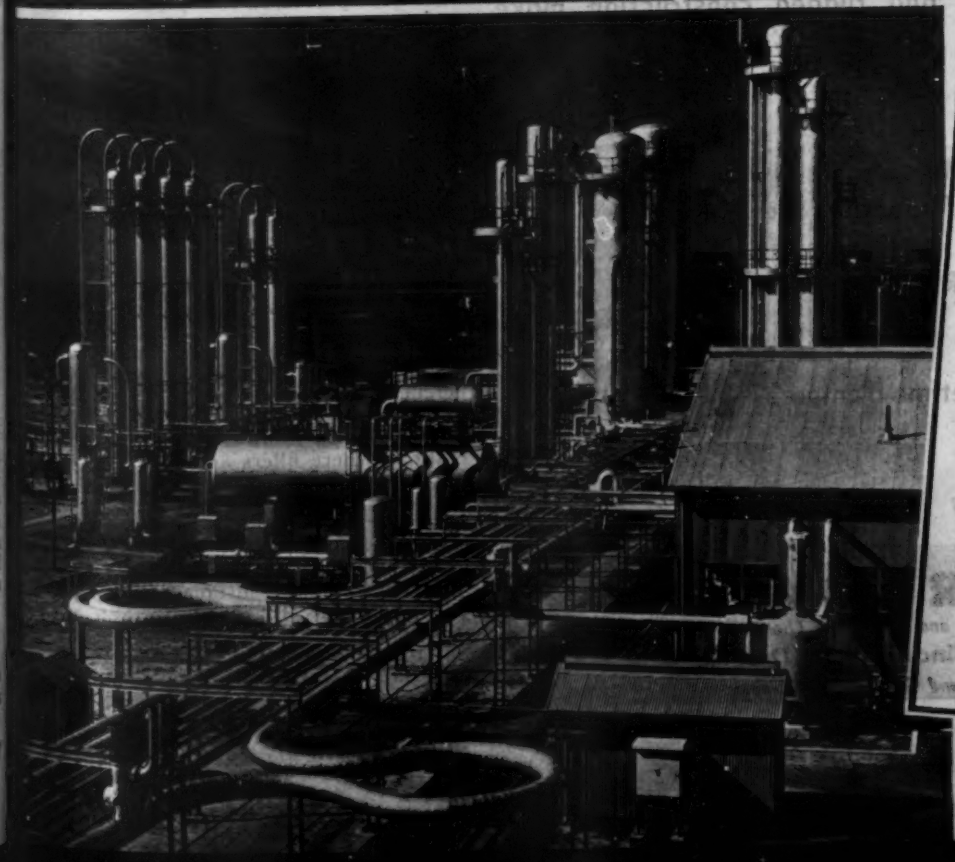
During recent years many ceramic pieces, particularly steatite parts for radio and radar equipment, have been manufactured by automatic high-pressure extrusion. The body mixes are generally molded in a nearly bone-dry condition, and therefore require an agent to permit them to exhibit plastic flow as well as a binder to maintain rigidity in the pressed pieces. An emulsion of a microcrystalline wax especially selected because of its toughness and adhesiveness has been found extremely suitable for this work. Many of these steatite parts and such other ceramics as porcelain and chinaware are finished with a glaze, in which a different wax emulsion has been found to be effective as a binder. Replacing starches and natural gums speeds production and produces more uniform glaze coatings.

Wax Emulsion Uses

The list of other uses of wax emulsions is long; a few are the polishing of clothes







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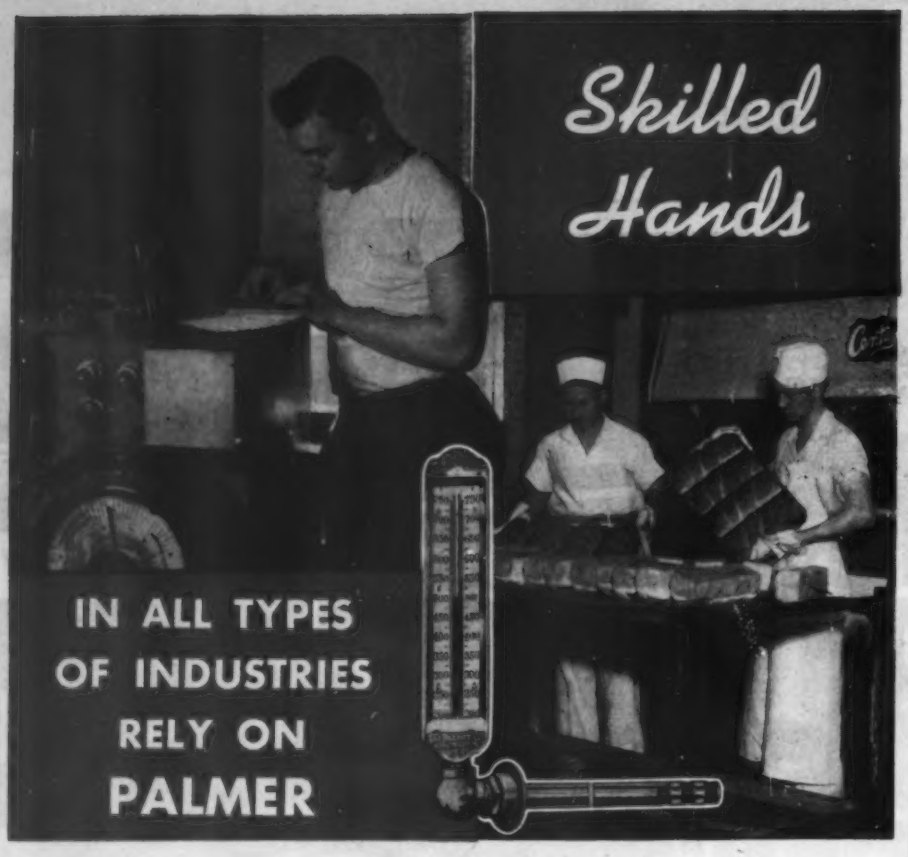

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pins, the treatment of nursery stock during transplanting, the waterproofing of burial vaults, and as an additive for starch in laundries.

Wax emulsions illustrate the fact that certain basic petroleum products must be compounded to render them useful. A second field of activity where such compounded products are widely used is in the manufacture of textiles. Since practically all types of textile fabrics utilize them at some point in their manufacture, petroleum is becoming of greater importance with each passing year. The textile industry is old and has employed fatty oils as processing materials since its earliest beginnings, but petroleum is fighting a winning battle against the prejudice of generations of artisans who have passed down their knowledge by word of mouth from father to son. The textile field is broad and includes woolen and worsted fabrics, cottons, rayons, and cordage fibers, all of which are treated with petroleum oils of some type.

In the processing of woolens and worsteds, it is necessary that the fibers be lubricated to prevent breakage during the combing, spinning, and weaving operations to which they are subjected. Wool as it is sheared from sheep is covered with wool grease, but this fat is lost when the raw wool is scoured to clean it of dirt. Therefore, nature's lubricant must be replaced before the clean wool can be handled further. When fatty oils are used in processing they are applied as crude emulsions made by adding them to warm solutions of caustic and alkali. A more modern method is the use of self-emulsifying petroleum oils, which produce highly staple emulsions when added to water.

Mineral oils have several advantages in this use. They do not become rancid with age, as do some fatty oils, and therefore cannot become spontaneously ignited as in extreme cases of autoxidation. In addition pretroluem products provide better lubrication of the fibers because fewer fibers are broken during processing and the formation of a stronger yarn results.

After the lubricated woolen fibers have been processed to woven cloth, the lubricant has carried out its appointed task, and must be removed. This is accomplished in the "fulling" and "scouring" operations in which the cloth is wet with a concentrated solution of soap and alkali and is subjected to a pounding which cause it to shrink. This contraction in length and width renders it thicker or fuller, hence the term "fulling." When fulled to the proper degree, the cloth is scoured or rinsed by passage through a succession of warm- and cold-water baths during which the dirt, alkali, soap, and oil are removed simultaneously. The finished wool, originally oiled with 3 to 10 percent of lubricant, has had its oil content reduced to 0.5 percent or less.

In the case of cotton goods, petroleum is used largely in finishing or sizing operations where fillers and softening oils are applied to the cloth to improve appearance and hand, and to increase weight or body. Sizing materials such as starches and gums are generally quite brittle, and therefore require a softening agent. In many instances, petroleum oils of various types and certain petroleum waxes can successfully perform this plasticizing action. Numerous types of sizing operations are employed with cotton goods—for example, the sizing of

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warp threads, heavy back fillings of book-binding cloth, and plain sizing of cotton dress fabrics and similar materials. In addition there are certain emulsifiable petroleum products that are used in the Sanforized process as softeners and as agents to improve the rewetting properties of the cloth.

The rayon industry is a particularly large user of petroleum oils which are employed as lubricants for the rayon fibers. While only very small percentages of oil are applied, tremendous quantities of rayon are produced and the consumption is so large that the oils are usually purchased in tankcar quantities. A less important application in rayon processing is their use in soaking oils which serve as softeners for the gums and starches used in the manufacture of rayon crepes and rayon stockings. These mixtures are applied to the yarn before knitting or weaving to set the twist, but are washed out after these operations, thus releasing the fibers and permitting them to develop the characteristic texture of the fabric.

The processing of cordage fibers such as jute, sisal, and hemp also requires the use of large quantities of mineral oils, petrolatums, and waxes. They are employed as lubricants, softeners, or waterproofing agents for the finished products in order to prolong their service life or to render them more useful for specific applications. Addition is most generally accomplished by direct application to the fibers either prior to or during stranding operations.

Petroleum By-Products

Mention should also be made of the numerous materials produced from petroleum by-products, some of which have become extremely important in both war and peacetime activities. Best known examples are naphthenic acids, petroleum resins, and petroleum sulfonates.

In the refining of certain West Coast gasolines and kerosines, it is necessary to scrub from them certain odoriferous and corrosive organic compounds, known as "naphthenic acids." These acids are formed by nature and are very similar in chemical composition to fatty acids. Like fatty acids they can be converted to soaps in which form they have their greatest utility. Soda soaps of certain naphthenic acids are used today in special death-dealing articles of warfare which cannot be described for military reasons. Lead, manganese, and cobalt soaps are excellent paint driers because they catalyze the setting of paint and varnish film. In addition copper soaps of naphthenic acids are extremely useful as fungicides and insecticides. The petroleum industry markets sizeable quantities of these copper naphthenates dissolved in either petroleum solvents or in ammonia for the treatment of wood and various cotton and cordage materials. When impregnated with small amounts of copper naphthenate, these cellulose products become resistant to attack by mildew and other fungi, teredoes, termites, and many related insects. In this preservative treatment it is actually the copper which is the active ingredient, but its action is intensified by combination with naphthenic acids. A great variety of articles have been so treated, including sand bags, tent material, ropes, tent shrouds, camouflage netting, marine hawsers, bottoms of wooden ships, marine pilings, fish nets, and tobacco netting.

Other by-products from petroleum

which have found wide use in industry are the so-called "petroleum resins" which are materials extracted from gasoline to reduce gum-forming tendencies. They are useful because of this characteristic, and upon exposure to air they dry to hard varnish-like films. They are employed as extenders for difficulty obtainable paint-and varnish-making oils, are applied to metals as protective coatings, and serve as binders for sand in preparing foundry cores for casting metals.

Mineral oil sufonates are a third group of important by-products. Chemically they are mixtures of sodium soaps of sulfonic acids formed in the refining of petroleum oils with sulfuric acid. Depending upon their molecular weight, which in turn is related to viscosity, they are either water soluble or oil soluble in nature. The water-soluble sulfonates are powerful wetting agents and detergents, and have great utility in a myriad of applications. One of the main uses of a wetting agent is in the dyeing of textiles where it is essential that water will wet the cloth rapidly and uniformly and permit it to become evenly dyed to the proper shade.

Mineral oil sulfonates of the detergent type are used as important ingredients in special hard water-, and salt water-resistant soaps for the armed forces. Mineral oil sulfonates of the emulsifying agent type are useful for the manufacture of self-emulsifiable oils, such as cutting oils, and also many of the newer type rust preventives.

Rust Preventives

Rust preventives are of extreme importance in many phases of industry's war activities. Practically all metal articles made for the armed forces, such as precision parts, instruments, tools, replacement parts for automotive and aircraft engines and machine tools must be protected against rusting with products which can be removed before the articles are used or will not impair operations if allowed to remain. This is accomplished by coating them, or at least their most susceptible parts, with a rust-resisting film of one of a great number of special compounds designed for this service.

Practically all the commonly-used rust preventives have a petroleum base of oil, petrolatum, or wax which is commonly used compounded with other materials to enhance its properties. Products are available to give protection against all degrees of rusting, which may be experienced indoors or outdoors, in the rain, in the sun, and on exposure to salt water. Rust preventives are highly specialized products because such a diversity of service conditions must be met, and because such factors as the ease of application and removal, and the type of film required must be taken into consideration.

With the present shutdowns of certain war plants, there is a need for different types of rust preventives which will have a longer service life than those used on war materiel. These materials are necessary for the protection of equipment to be stored away for future use or held in readiness for resumption of war production.

Uncompounded Oils

Most of the products mentioned thus far are compounded materials that were developed for specific uses. In addition to these the petroleum industry produces a wide variety of uncompounded oils

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which are extremely valuable in processing applications.

For years the industry has produced a number of highly refined oils such as the so-called "white oils" which are used for medicinal purposes. Because these these oils are so pure, and so bland in reaction, they are also used in cosmetics, hair oils, ointments, and even in animal feeds. Other less highly purified oils made by various methods of refining are employed in packing houses for slushing chutes, tables, knives, and hooks during shutdown periods. Such products are also used as ovicides in tree sprays, as impregnants for wrapping papers and fruit wraps, and in the preservation of eggs.

The rubber industry is a large user of uncompounded petroleum products, since it consumes at least one part of petroleum for each six or seven parts of rubber. Were it not for petroleum products it would be virtually impossible to convert many of the basic synthetic rubbers into useful articles of trade. For example, it was only when the rubber industry employed certain special asphalts that it was able to produce a GR-S tire which would approach a natural rubber tire in wearing and aging qualities. When petroleum products are compounded into rubber they assist processing and may impart such desirable properties as long life, flexibility at low temperatures, softness, and resistance to abrasion to the vulcanized articles. It is also of interest in this connection that a number of synthetic oils have been produced from petroleum which have found use in certain specialized rubber compounding operations.

With further reference to synthetic oils, brief descriptions of two unique products made from petroleum may be of interest, The first of these is an oil employed for the inspection of raw quartz which is to be cut into quartz oscillators that control wave length in radar and radio equipment. These oscillators can be made only from sections of raw quartz crystals which have no internal imperfections, and in addition must be cut at very definite angles with respect to both optical and electrical axes of the crystals. The crystals must therefore be inspected, but since most raw quartz is scarred and has many opaque surfaces, careful study of the interior is often impossible. However, this can usually be accomplished by immersing the quartz in a liquid having the same refractive index, upon which the crystal boundary becomes invisible. Since light is not bent in passing through the liquid-solid interface, surface flaws no longer obscure the internal defects. Since inspection cannot be accomplished with conventional petroleum oils because of their low refractive index, this operation was originally accomplished with chemicals which are highly odoriferous, and somewhat irritating to human skin. Later a petroleum product was developed in which these undersirable properties were reduced appreciably without loss of efficiency of inspection.

The second synthetic oil is one that is being employed for the control of mosquitoes. Heretofore the commonest methods of chemical control were to spray infested bodies of water with fuel oil, kerosine, or crankcase drainings. This treatment is effective because mosquito larvae breath at the surface of the water, and are smothered when their respiratory organs become filled with the surface oil. The main drawbacks to the surface treatment are that on large areas, the oil becomes blown away by heavy winds or evaporates in warm weather. As a result of these adverse conditions, oiling must be repeated every ten days or two weeks to insure the continuity of the surface film.

Quite recently, studies have been made of mosquito control with a light-bodied synthetic oil which is heavier than water. This product, which is applied in emulsion form, has been used successfully for controlling pest mosquitoes of the culex and culicini families. The larvae of these tribes feed on the bottom, and for unexplained reasons are attracted by the oil, feed upon it, and soon become poisoned. The use of an emulsion of this high specific gravity oil overcomes the drawbacks of surface oils, because wind will not blow it from the surface nor will it evaporate. Treatment of infested areas with the synthetic product need be made only a few times a season instead of every ten days.

Based on addresses given by the author before the Chicago and New York districts of the ASTM. Reprinted from Chemical and Engineering News, July 10, 1945.

Recently Elected to Head California Association

M. L. ARNOLD

recently elected president of California Natural Gasoline Association, has been active with that group since 1926. After a degree in chemistry at University of Oklahoma in 1923, he went to work with Signal Hill Gasoline Company as chemist, and following merging of that company with Richfield Oil Corporation, advanced through various plant jobs to chief engineer of the gas department. He became a director of CNGA in 1940, and vice president in 1944. He has served on the association's technical and charcoal-test committees.

M. W. KIBRE

new vice president of California Natural Gasoline Association, has discharged many committee assignments since he became a member in 1929. Educated as a chemist and engineer at University of California, he started with General Petroleum Corporation as a laboratory technician at Santa Fe Springs, was promoted to chief chemist, and later transferred to Vernon as engineer in the gas department. Later he became superintendent, general superintendent and recently assistant manager of the gas department of the company.

Socony Shale Research Donated to Bureau of Mines

Socony-Vacuum Oil Company, Inc., announced July 26 that it had placed at the disposal of the United States Bureau of Mines the result of its research on a method of extracting oil from shale.

"While the extraction costs are too high for present commercial operation," the announcement said, "the method makes available when necessary an estimated 90 billion barrels of petroleum.

"Representing experiments conducted at the company's Paulsboro, New Jersey, laboratories during the past two years, the information includes engineering and technical data, complete descriptions of processes, blueprints and facilities for developing the 400 billion tons of oil shale, principally located in Colorado, Utah and Wyoming. The shale, now mined at the surface only, varies in oil richness.

"It is estimated that mining and crushing the shale probably will cost $2.20 per ton—too expensive for present commercial use, but nevertheless a safeguard in case a shortage of natural crude should send the crude price up to $3.75 or $4.00 a barrel. In their experimental studies, Socony-Vacuum scientists recovered between 17 and 40 gallons of oil from each ton of shale, depending on operating conditions, the highest yield representing 15 percent by weight of raw shale.

"Crude shale oil recovered from the retorting process is very waxy, highly unsaturated and high in sulphur and nitrogen."

THE MONTH IN THE INDUSTRY

STEPPING up of the war in the Pacific has made necessary a switch in the refining program, with less emphasis upon aviation gasoline and more upon fuel oil. Some plants which have been producing components for aviation gasoline are being put back to making regular products, and fuel for the planes will come from the plants built especially for that purpose.

Oil needs of the Pacific war were discussed at the July meeting of Petroleum Industry War Council. It was stated domestic production of crude oil must continue above the "maximum efficient" rate, but it was warned that state regulators should stand ready to cut back immediately upon war's end, both to conserve the wells and prevent an excessive accumulation aboveground. Meantime production keeps making new peaks from week to week, and Petroleum Administration for War has set the August quota at 4,900,000 barrels of crude oil and 339,100 barrels of other liquids daily, an increase of 11,000 barrels over July. Texas is to provide 10,000 barrels of the increase.

Federal Power Commission has set September 18 for opening of its hearings on natural gas at Kansas City. Spokesmen for the commission have reiterated that it is not interested in oil, but many concerned are fearful that federal dickering with natural gas cannot but effect oil because of close association.

Harold L. Ickes is out as Secretary of the Interior and in again as rumors revolve from week to week. Treasury Secretary Morgenthau's replacement, and conflicts on whether or not he was fired, served to keep alive speculation as to when Ickes will go. President Truman indicated that Ickes will go to London to negotiate the Anglo-American oil agreement, which would mean his retention until after that chore, but Ickes has indicated that if he is going out soon it might as well be now. The President has his letter of resignation on his desk, and may get around to acting upon it after he has completed conferring in Europe.

A spokesman for Office of Price Administration in a statement to the O'Mahoney oil investigating committee said that industry pleas for consideration of replacement costs in fixing crude-oil prices is a device to justify an increase which otherwise could not be supported.

Five restrictive orders were modified by PAW July 13 as it "sought to free the industry from government control as rapidly as possible."

Enactment of legislation abandoning all federal claims to underwater oil deposits has been recommended by a House committee. Action probably will be had when the House completes its vacation.

Suppression of Germany's synthetic-oil industry, as one step toward saving the next generation from another world war, is receiving favorable consideration in Washington. Aside from serving as a security measure, such a move would safeguard the petroleum interests of the United States and England, both looking for postwar world markets and fully aware of the possibility that German science might lick the cost factor in synthetic oil manufacture—also of Russia, which sooner or later may come into the world market as a seller if her internal economy permits, in an effort to obtain foreign exchange needed for material and equipment purchases here and in other countries. American millions and years of research will be saved by reason of German developments, a recent United States mission discloses.

The FPC investigation of natural-gas transportation will not be the only probe of pipe lines to be undertaken this year. Shortly after the commission gets into its stride, the Senate Petroleum Investigating (O'Mahoney) Committee is expected to hold hearings on the disposition of war-emergency pipe lines, to be followed by a House investigation of transportation generally, which will include both gas and oil pipe lines.

Tank-car movement of West Texas crude oil to the Pacific Coast is increasing. Longview unloading facilities are being checked for daily movement of 25,000 barrels Permian oil to serve the Big Inch.

Humble Oil & Refining Company failed in its appeal to the circuit court to have government seizure of its plant at Ingleside abated. The seizure was made on Presidential assumption that labor disturbance was in prospect. So far as has been made public, labor conditions and operations at the plant are normal. The Texas Company's Port Arthur plant is operating normally under government supervision. The excuse for seizure there was a strike by negro workers dissatisfied by FEPC propaganda with their chances of upgrading. A similar situation involving both negroes and Mexicans still simmers at the Houston plant of Shell Oil Company. A controversy at the latter plant regarding the number of workers needed to operate a new unit appears to have been ironed out. Sinclair Rubber, Incorporated, processing butadiene from Sinclair Refining Company's plant at Houston and from several nearby plants, has been seized by the government because of prospect of a labor stoppage. This plant is adjacent to a tire plant that was picketed some weeks ago but on which work was not stopped until orders were received to halt construction as this plant had been ruled surplus.

Another turnover in administration of the rubber program was announced, with Robert S. Wilson, vice president of Goodyear Tire & Rubber Company, succeeding John L. Collyer, president of The B. F. Goodrich Company, as special director of WPB rubber programs. Collyer reported that military and minimum essential civilian requirements can be met during 1945 and 1946 through the programs and policies in effect provided problems of manpower and components supply, particularly textiles, can be solved. Major obstacle to the attainment of 1946 production objectives is natural rubber. To meet the drain on the limited stockpile, expected to drop to 66,000 tons by the end of the year, Rubber Reserve Company is arranging to harvest the entire U. S. guayule acreage by April, 1947, and Rubber Development Corporation is extending its contracts with rubber-producing south and Central American countries beyond the original 1946 termination.

It Takes More Fuel Oil to Get Within Shooting and Bombing Range of Japs

"From now on this is largely a fuel-oil war," Dr. Robert E. Wilson, chairman of the committee on economics, told the Petroleum Industry War Council at its July session. It requires about 21,000 barrels of fuel to deliver 100,000 barrels of gasoline from the Gulf Coast to the Pacific theater, including the return trip of the tanker, as compared with 8000 barrels for an equal delivery to Europe, he said.

The committee reported that crude oil, condensate, natural gasoline and benzol production are expected to total almost 5,200,000 barrels per day during the last half of this year.

"At Expense of Gasoline"

"Earlier Navy diesel-fuel programs have resulted in substantial losses of normal production of burning oils for this winter and the operation of catalytic cracking units for the 100-octane program has further reduced kerosine and distillate fuel yields," it was stated. "Unless more crude oil can be obtained and run, it appears that a substantial increase in the yield of distillate fuel and kerosine at the expense of gasoline will be necessary to avert a serious situation next winter. Even this would not allow for prospective demands to offset possible coal shortages either here or in Europe."

In a long-term survey of the supply situation, carried through to June 30, 1946, the committee reported that total civilian, military and export demand reflected against the United States as part of the United Nations' requirements is in excess of the available supply, even after maximizing the supply of products from the United States and the reduction of inventories in this coun-

THE MONTH . . .

try to minimum operating levels, by 30,000 barrels daily for the current quarter, 129,000 barrels for the fourth quarter, 154,000 barrels for the first quarter of 1946 and 116,000 barrels for the second quarter.

However, this represents less than 2 percent of the total demands of the United Nations, and steps already are being taken toward reduction, partly through further increased output in the Caribbean and Persian Gulf areas.

On the assumption that the Pacific war will continue, that increased gasoline allocations will be maintained and that the recently revived probihition on the application of road oil will remain in effect, the committee foresaw a total demand rising from 5,378,000 barrels daily this quarter to 5,489,000 in the fourth quarter and 5,721,000 in the first quarter next year, dropping back to 5,555,000 in the second quarter. Against this, new supply, including imports which are scheduled to rise steadily throughout the four quarters from 189,000 to 269,000 barrels daily, will be 5,387,000 barrels daily this quarter, 5,354,000 barrels in the next quarter, 5,377,000 in the first quarter of 1946 and 5,366,000 in the second quarter.

"The anticipated large supply will still be inadequate to meet indicated demands," it was warned. "It will be necessary to reduce stocks substantially in order to satisfy as much of the demand as possible."

Still Runs to Increase

Runs to stills are estimated at 4,884,000 barrels daily this quarter, 4,890,000 in the fourth quarter, 4,892,000 in the first quarter next year and 4,890,000 in the second quarter. The principal problems with respect to yields, it was figured, will apparently relate to Navy diesel and Navy special fuel oil, in which shortages are anticipated; kerosine also will be short, due in part to the projected demands for jet propulsion fuel, and a shift in the yields of military and civilian grades of gasoline appears to be necessary.

Gas Industry Getting Ready Data for FPC Investigation

Federal Power Commission having set a hearing on interstate transportation of natural gas to open at Kansas City on September 18, has assured representatives of the oil industry that it will not concern itself with oil.

Meanwhile Independent Natural Gas Association of America and other interests in the natural gas industry are active in preparation for the hearing. A steering committee has been named.

L. S. Reid Rejoins Staff Of University of Oklahoma

Laurance S. Read has again joined the College of Engineering of University of Oklahoma as professor of chemical engineering. His duties will be divided between teaching and research. At present he is making studies on natural gas dehydration and other problems dealing with production, gathering and processing of gas-condensate mixtures at high pressures.

LAURANCE S. REID

Reid received a B.S. degree in chemical engineering at Iowa State College in 1931, and after a period with Lion Oil Refining Company attended University of Oklahoma in 1936 and 1937 to obtain his masters degree in chemical engineering. He joined the research division of Phillips Petroleum Company in 1937, and had moved to development engineer for Black, Sivalls & Bryson when he became associate professor of chemical engineering at University of Oklahoma in 1940, where he remained until 1943, at which time he went with Southern Natural Gas Company as assistant chief engineer. He leaves the latter connection to return to the university.

Indiana Standard Forms Chemical Department

Standard Oil Company (Indiana) is organizing a chemical products department, with William B. Plummer as manager and under general direction of Bruce K. Brown, vice president in charge of development. It was indicated present plans call for sale of the petroleum-based chemicals to be manufactured as basic materials rather than consumer products. Howard R. Peterson of the company's sales technical service will be in charge of sales development.

Plummer until recently was a lieutenant colonel in the Air Technical Service Command. Before the war he was head of the company's development and patent department.

Houdry Announces Two Appointments

Houdry Process Corporation has announced appointment of John E. Ford, Jr., as an executive assistant, and of Gordon A. Kessler to head the corporation's patent division.

Ford for the past eight years has been with The M. W. Kellogg Company. During 1941 and 1942 he was project engineer on the synthetic-rubber plant construction at Sarnia, Ontario. His most recent position has been sales engineer and executive assistant to the vice president in charge of sales. He

Crude Oil Runs to Stills, Production of Refined Products, and Stocks for the Four-Week Period Ending July 28, 1945

(Figures, in thousands of barrels of 42 U. S. gallons each, based on reports of American Petroleum Institute. Production and stocks include reported totals plus estimated amounts to make these figures on a Bureau of Mines basis)

DISTRICT	Capacity Percent Reporting	Crude Runs to Stills: Daily Average	Crude Runs to Stills: Percent Operating	Production: Gasoline*	Production: Kerosine	Production: Gasoil and Dist. Fuel Oil	Production: Residual Fuel Oil	Stocks at Refineries, Terminals and in Pipe Lines: Finished and Unfinished Gasoline	Stocks at Refineries, Terminals and in Pipe Lines: Kerosine	Stocks at Refineries, Terminals and in Pipe Lines: Gasoil and Dist. Fuel Oil	Stocks at Refineries, Terminals and in Pipe Lines: Residual Fuel Oil	Crude Oil: Daily Average Production	Crude Oil: Stocks†
East Coast	99.5	772	97.6	7,341	836	3,901	6,824	13,392	4,316	9,083	6,389	.....	.....
Appalachian District 1	76.8	96	66.1	1,298	227	339	311	2,833	301	537	266	.....	.....
Appalachian District 2	81.2	52	105.0	606	34	126	364	1,298	61	114	120	.....	.....
Indiana, Illinois, Missouri	87.2	811	96.4	11,505	1,164	2,563	4,295	19,204	2,159	5,083	2,701	.....	.....
Oklahoma, Kansas, Missouri	78.3	390	83.2	5,603	482	1,847	1,916	8,295	892	2,263	1,395	.....	.....
Inland Texas	59.8	238	72.1	3,903	319	459	1,774	2,780	262	552	969	.....	.....
Texas Gulf Coast	89.3	1,182	95.6	15,328	1,613	5,325	6,939	16,149	1,258	5,625	5,526	.....	.....
Louisiana Gulf Coast	96.8	273	104.9	3,730	944	1,575	1,404	4,483	648	1,683	1,091	.....	.....
North Louisiana, Arkansas	55.9	88	69.8	992	233	293	572	1,814	672	960	206	.....	.....
Rocky Mountain District 1	17.1	13	98.1	173	21	32	95	97	15	21	38	.....	.....
Rocky Mountain District 2	72.1	244	76.9	1,533	37	351	1,089	2,160	112	340	608	.....	.....
California	87.3	930	93.3	9,955	208	2,949	11,649	13,503	385	9,810	22,974	.....	.....
Total U. S. July 28, 1945	85.8	4,968	91.4	61,967	6,080	19,760	37,232	85,998	11,081	36,071	42,283	4,926	218,108‡
Total U. S. June 30, 1945	85.8	4,940	90.9	61,301	6,154	20,108	37,320	86,472	9,676	32,213	40,488	4,903	220,781
Total U. S. July 29, 1944	.....	4,629	.....	.....	.....	.....	.....	81,296	11,490	37,805	56,667	4,608	225,112

* Includes natural gasoline blended at refineries. † Bureau of Mines. ‡ July 21, 1945.

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THE MONTH . . .

JOHN E. FORD, JR.

began his experience in the petroleum industry after graduation from Georgia School of Technology where he received his bachelor degree in chemical engineering. His early experience included service in the technical department of Sinclair Refining Company at Houston.

Kessler holds a degree in industrial chemistry from University of Maryland, and a law degree from New York University. He has been employed for a number of years as a patent attorney with The Texas Company, previously held a similar positon with Allied Chemical & Dye Corporation, and has been an examiner in the United States Patent Office.

G. A. KESSLER

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, Illinois, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

1,2,4-Trihydroxy benzene
Methyl ethyl acetaldehyde
Decahydro acridine
2,5-Diaminobenzene sulfonic acid dihydrochloride
n-Amyl thiourea
Rufigallic acid
Istizin
Gentisin
Chrysophanic acid
Rhein
Munjistin
Thioformamide
Chloracteo-n-dodecylamide
Phenyl thiourea
2,6-Dimethyl nitrobenzene
Emodin
Sodium sulfoxylate
Anthraquinone-1,5-disulfonic acid
Octadecene-9
Divinyl Ketone
Vinyl thiocyanate
Oxetone
Methyl tetrolate
o-Phthalic dialdehyde
2,2-Dibrompropane

Gerhold Heads Universal Laboratory at Riverside

C. G. Gerhold has been appointed manager of Universal Oil Products Company's research and development laboratories at Riverside, Illinois, where he succeeds R. B. Day. Gerhold previously had been head of the development department.

Day, manager of the laboratories for the past seven years, was relieved of his duties at his own request.

Dr. L. S. Kassel remains as technical coordinator.

C. G. GERHOLD

New York Junior Engineers Elect Officers

Junior Chemical Engineers of New York, 330 W. 42nd St., New York 18, recently elected the following officers for the coming year: William B. Hudson, Foster Wheeler Corporation, president; Maurice R. Lyons, The M. W. Kellogg Company, vice president; Richard Rosencranz, Shell Oil Company, secretary-treasurer, and Andrew A. Melnychuk, Celanese Corporation, assistant secretary-treasurer.

Zola G. Deutsch, chemical engineering consultant, was elected to honorary membership, a status already held by Walter J. Murphy, Stephen L. Tyler and Sidney D. Kirkpatrick, all of whom, among "senior" engineers, have taken particular interest in the progress of the junior group.

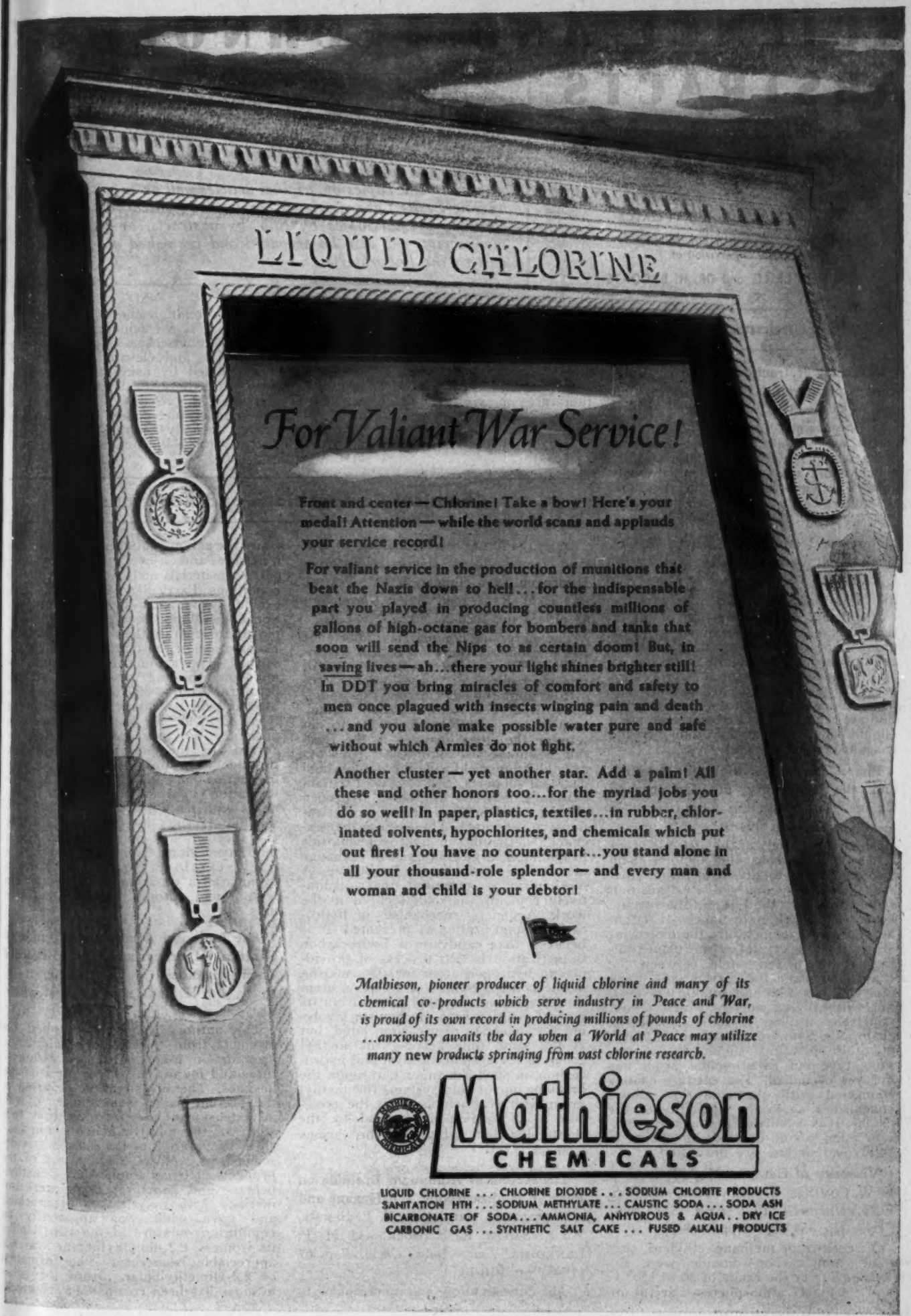
Announcing the successful completion of its eighth year of existence, the New York society points to its own continued growth as a source of encouragement to young engineers in other areas who may have contemplated formation of similar organizations. By opening membership to any young chemical engineer in the area, and by securing outstanding speakers for its monthly meetings, the society has grown to nearly 100 members.

Kingman Manager for Union At Los Angeles Refinery

Kenneth E. Kingman recently was made manager of Union Oil Company of California's Los Angeles refinery, where he succeeds P. S. Clark, resigned.

Kingman entered the research and development department of the company in 1929, following graduating B.Sc. from California Institute of Technology. In 1935 he transferred to the manufacturing department as assistant superintendent of operations at Los Angeles refinery. He moved to Oleum refinery in 1937 as assistant superintendent, and was superintendent of compounding, asphalt and shipping at the latter plant from December, 1944, until his promotion to manager at Los Angeles.

K. E. KINGMAN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The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Molecular Refraction—Viscosity Constant Nomograph. R. T. LAGEMANN. *Ind. & Eng. Chem.* **37** (1945) p. 600.

It is possible to determine the viscosity of a liquid from its refractive index which is easy to measure and for which many data are frequently available. The equations used in the construction of a nomograph are presented, and a nomograph is included.

Heats of Isomerization of the 18 Octanes. E. J. PROSEN AND F. D. ROSSINI. *J. Res. Natl. Bur. Standards* **34** (1945) pp. 163-74 (Res. Paper 1635).

The heats of isomerization of all of the 18 octanes were determined by measurement of the ratios of their heats of combustion, in the liquid state for 17 and in the solid state for 1. A procedure previously described by the authors was used. Values of the heats of isomerization are reported for the condensed state (liquid or solid) at 25° and for the gaseous state at 25° and 0° K.

Phase Transitions of Solid Paraffins and the Flexibility of Hydrocarbon Chains. H. FROEHLICH. *Trans. Faraday Soc.* **40** (1944) pp. 498-502.

Theoretical study of the dielectic properties of solids consisting of long chain molecules led to the conclusion that such solids may undergo a λ-transition (connected with the jump in the specific heat without the apperance of latent heat). At low temperature the molecules of a paraffin crystal form plane zigzags with a fixed angle between the chain planes and the crystal axes. Each molecule has a second equilibrium position with higher energy which is obtained by turning it 180° around the chain axis. Some of the transition points of other paraffins should be of the same type but experimental proof has not yet been had. The entropy change connected with the transition allows conclusions as to the flexibility of the chains. It is calculated that at the transition point about half of the chains in solid pentadecane are untwisted.

Viscosity of Gases at High Pressures. E. W. COMINGS, B. J. MAYLAND, AND R. S. EGLY. *Univ. Ill. Eng. Expt. Sta. Bull.*, Series No. 354 (1944) pp. 7-68.

Viscosities of methane, ethylene, propane, and carbon dioxide were determined over the range of 30 to 150° C. and 4.4 to 117 atmospheres. Careful analysis of the errors showed the results to be accurate to within 1%. Data in the literature on viscosity were critically surveyed and studied and the most reliable were used, along with data obtained in the investigation, to construct general correlation curves based on the principle of corresponding states. The approximate viscosity of a gas at any temperature and elevated pressure can be calculated by using the correlation curves and the critical temperature and pressure if the viscosity is known at the same temperature and at a pressure low enough (usually 1 atmosphere) for the viscosity to be independent of pressure.

Chemical Compositions and Reactions

Investigation of the Mechanism of Butane Isomerization Using Radioactive Hydrogen as a Tracer. T. M. POWELL AND E. B. REID. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 1020-26.

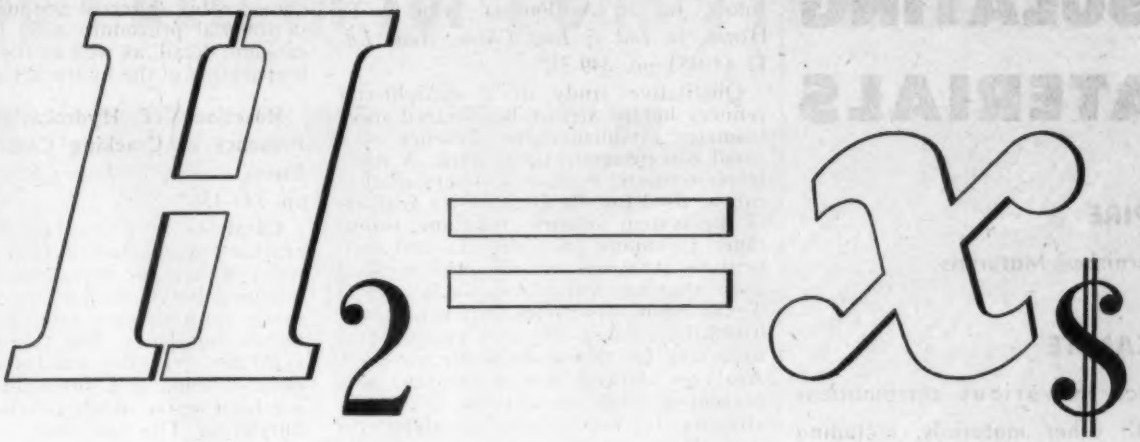
The increasing commercial importance of the isomerization of paraffin hydrocarbons has rendered a knowledge of the mechanism of these reactions of greater importance. Utilizing the radioactive hydrogen isotope, called tritium, as a tracer, an effort was made to determine the steps involved in the reaction, n-butane=isobutane, as carried out over aluminum chloride on alumina and charcoal supports. The results of tritium exchange between hydrogen, hydrogen chloride, and butanes during isomerization are presented. These show that exchange of tritium in hydrogen chloride to butane is large compared to exchange of trituium in hydrogen to butane. A mechanism is proposed that qualitatively explains the data secured in the work. A general mechanism of hydrocarbon isomerization is presented. It is believed that catalysis of hydrocarbon isomerization is that process of providing an hydrogen atom for the entering of the bonding sphere of a carbon atom thus displacing a methyl group from its normal position by a mechanism involving the inversion of a carbon bond, but at the same time keeping the methyl group in the system, catalyst plus hydrocarbon, in such a manner that, upon the breaking up of this system, the methyl group will reattach itself to the molecule in a position determined by the thermodynamic stability of the various isomers.

The Action of Aluminum Bromide on Paraffin Hydrocarbons. I. n-Hexane and n-Heptane. O. GRUMMITT, E. E. SENSEL, W. R. SMITH, R. E. BURK, AND H. P. LANKELMA. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 910-14.

The investigation was undertaken to study the action of aluminum bromide on n-hexane and n-heptane using highly purified materials and carefully controlled conditions. Particular care was taken to exclude water and air. Efficient fractional distillation equipment was employed to separate the reaction products. Preparation of the materials used is described. The action of aluminum bromide on n-hexane was studied at temperatures from —30° to room temperature and on n-heptane at temperatures from 22 to 98° C. In the absence of a promoter no appreciable reaction occurred. In the presence of hydrogen bromide as a promoter, cracking, isomerization and alkylation occur with formation chiefly of branched chain paraffins with methyl groups in the 2-position The results indicate that cracking is preceded by isomerization. Under mild conditions isomerization is the chief reaction. No normal paraffin, cycloparaffin or aromatic hydrocarbons were found among the reaction products.

The Action of Aluminum Bromide on Paraffin Hydrocarbons. II. Branched Chain Hexanes. J. W. BISHOP, R. E. BURK, AND H. P. LANKELMA. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 914-18.

The authors previously studied the products from the action of aluminum bromide on n-hexane at low temperatures and found that they were isomeric hexanes. The investigation reported in the present paper was concerned with an extension of the previous work to a study of the four branched chain hexanes. Preparation of the materials is described, as well as the analysis of the products. It was found that 2-methylpentane and 3-methylpentane were isomerized with only traces of cracking and gave what was apparently an equilibrium mixture of the two. Unlike its isomers, 2,2-dimethylbutane was not appreciable isomerized. The formation of 2,2-Dimethylbutane from the other hexanes has been correlated with crack-



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ing 2,2-dimethypropane and normal paraffin hydrocarbons were absent in all reaction products studied.

Neopentane in Refinery Butanes. L. C. JONES, JR., R. A. FRIEDEL, AND G. P. HINDS, JR. *Ind. & Eng. Chem., Anal. Ed.* 17 (1945) pp. 349-51.

Qualitative study of a straight-run refinery butane stream by infrared spectrometry established the presence of a small percentage of neopentane. A spectrophotometric method is described that can be used for the quantitative analysis of the system propane, n-butane, isobutane, isobutane, neopentane, and isopentane. Analyses made by this method show that neopentane occurs in several Texas crude oils to the extent of about 0.03% by volume. The reference spectra necessary for this analysis are included. Analyses showed that neopentane was present in some straight-run C_4 refinery streams to the extent of about 0.4 mole %.

Catalytic Cracking of Pure Hydrocarbons. B. S. GREENSFELDER AND H. H. VOGE. *Ind. & Eng. Chem.* 37 (1945) pp. 514-20.

Catalytic cracking of petroleum fractions with silica-alumina or clay catalysts has been described in the literature in terms of commercial practice and products. However, most of the results have been obtained with petroleum oils containing a wide number of hydrocarbons. To secure insight into the chemistry of the process, the behavior of selected pure hydrocarbons has been studied under carefully controlled conditions in such manner as to make a comparison of catalytic cracking with thermal cracking possible. In the part of the work reported in the present paper the behavior of paraffin hydrocarbons from propane to paraffin wax was studied. A silica-zirconia-alumina catalyst was used in a small, fixed-bed cracking unit. It was observed that carbon-carbon bond ruptures are selective to give fragments of three of more carbon atoms. Secondary reactions include isomerization of the olefins, saturation of the olefins, and production of aromatics. A comparison with thermal cracking shows catalytic cracking is five to sixty times as rapid, is accelerated more for large molecules than for small ones, and gives considerably different products. The experimental procedure used is described in some detail, as well as the source and preparation of the hydrocarbons charged.

Reactions of Hydrocarbons in the Presence of Cracking Catalysts. C. L. THOMAS. *Ind. & Eng. Chem.* 37 (1943) pp. 543-45.

Catalysts as prepared for catalytic cracking were studied from the standpoint of their use in polymerizing propylene and butyle. It was found that synthetic silica-zirconia catalysts will polymerize butylenes. The three-component synthetic cracking catalysts, silica-zirconia-alumina and silica-alumina-thoria, are both active in the polymerization of butylenes. The polymers in every instance were liquids that boiled largely within the gasoline range. A C_8 fraction, when hydrogenated, had an octane number of 95.3. The apparatus used in the work and procedure are described. It was found that the catalyst became inactive with use because of the deposition of carbon. They could, however, be regenerated with air at 450-500° C., and the regenerated catalysts were as active, or more active than the first catalysts. It was found that isobutylene polymerized more readily than n-butylenes.

Impurities in Benzene. J. R. ANDERSON AND C. J. ENGELDER. *Ind. & Eng. Chem.* 37 (1945) pp. 541-43.

The purpose of the investigation was to characterize the saturated nonbenzenenoid hydrocarbon impurities of nitration grade benzene. The presence of cyclohexane, methylcyclohexane, 3-methylhexane or 3-ethylpentane, n-heptane or 2,2,4-trimethylpentane, 1,1-dimethylcyclopentane, and trans-1,2-dimethylcyclopentane was indicated. A small amount of toluene was also found. Certain unidentified impurities are believed to be olefins. The experimental procedure is described in detail.

Manufacture: Processes and Plant

Petroleum Processing Makes Gains of Widespread Significance. Chem. & Met. Report. *Chem. & Met. Engr.* 52 (1945) pp. 117-24.

The article reviews the wartime technological advances of the petroleum refining industry and notes with most potential significance to the postwar process industries. Among the subjects covered are: catalytic cracking, fluidized solids, aviation alkylate, butadiene for buna rubber, toluene for TNT, isomerization, superfractionation, heavy-duty oil, low-temperature greases, and special blending agents. The petroleum industry has become the recognized leader in process progressiveness because of intensive application of chemical engineering principles, large-scale unit production operation, inter-industry cooperation on a scale seldom encountered elsewhere, extensive and liberal research program, and high caliber personnel from operators to top management.

Catalytic Cracking of Cuts from Coastal Crude. D. B. ARDEN, R. H. NEWTON, AND G. L. BARCUS. *Ind. & Eng. Chem.* 37 (1943) pp. 546-51.

To obtain basic information on the chemistry of catalytic cracking, four close-boiling cuts from Coastal crude oil were cracked over synthetic silica-alumina catalyst at 650-900° F. and at 0.2-2.0 space velocity. The cuts studied had A.S.T.M. midboiling points of 307°, 406°, 543°, and 687° F. Pressure and catalyst activity were controlled to give catalyst deposits equivalent to those obtained in plant operation. The composition of the products secured was found to vary regularly with the severity of cracking. The more severe the cracking the higher the concentration of aromatics in the products, which indicated that the maximum concentration of cracked naphthenes will occur with moderate cracking. The moles of ring compounds decreased as severity increased, suggest-

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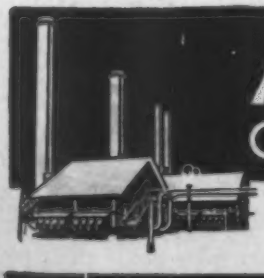

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ing a destruction of ring compounds and no net increase in ring compounds formation from chain material. The increase in aromatics was always less than the decrease in naphthenes, and apparently above 40 percent of the naphthenes destroyed appeared as aromatics. The production of hydrogen was less than that corresponding to simple dehydrogenation of naphthenes to aromatics. Under conditions of comparable severity of cracking the total production of olefins increased with increasing boiling range, while total isoparaffin production decreased. Both of these trends were more evident in the lower-boiling compounds. The ratio of iso to normal saturated hydrocarbons did not vary appreciably with charging stock or cracking conditions. The weight ratio of benzene:toluene:xylene averaged 1:6:16. The data are presented in some detail in tabular and also in diagrammatic form.

Fractional Distillation of Ternary Mixtures. Part I. A. J. V. UNDERWOOD. *Jour. Inst. Petr.* **31** (1945) pp. 111-18.

Equations are given for ternary mixtures with components x, y, and z that permit the compositions of the liquids on adjacent plates of a fractionating column to be calculated. By suitable transformation of these equations the composition on any plate can be calculated without using a stepwise procedure from plate to plate. Previously such a direct calculation has been possible only for the special case of total reflux. It is also shown that the principle of the method can be extended to mixtures of more than three components. The algebraic development of the equations is given in detail.

Globe-Valve Flow Coefficients for Valve Meters. A. E. KROLL AND H. V. FAIRBANKS. *Ind. & Eng. Chem.* **37** (1945) 588-91

The conversion of an ordinary commercial globe valve into a flowmeter is described. The valve flow coefficient, K_v, from which the rate liquid flow through a valve can be calculated, is defined in the following modified form of the fundamental flow equation:

$$K_v = 1.496w/\sqrt{p\Delta P}.$$

Valve flow coefficients for various valve settings on different sizes of Crane brass-globe bevel-seat brass-disk valves are presented, together details of the method by which they were obtained. These coefficients were determined with Reynolds numbers ranging from 30,000 to 150,000. It is shown that the use of a globe valve as a flowmeter is practical. Valve flow coefficients for three different ½-, ¾- and 1-inch valves were found to have a maximum deviation of 5%; and for 1¼-inch valves, only 3%. The valve flow coefficients presented agree within 3% with the values calculated by the Crane Company for loss of head through fully open, new Crane globe valves.

High Speed Agitator for Pressure Vessels. M. W. KIEBLER. *Ind. & Eng. Chem.* **37** (1945) pp. 538-40.

The paper describes an autoclave built with totally enclosed motor and agitator and for use under service involving pressure, temperature, and chemical attack. The autoclave illustrated was built to

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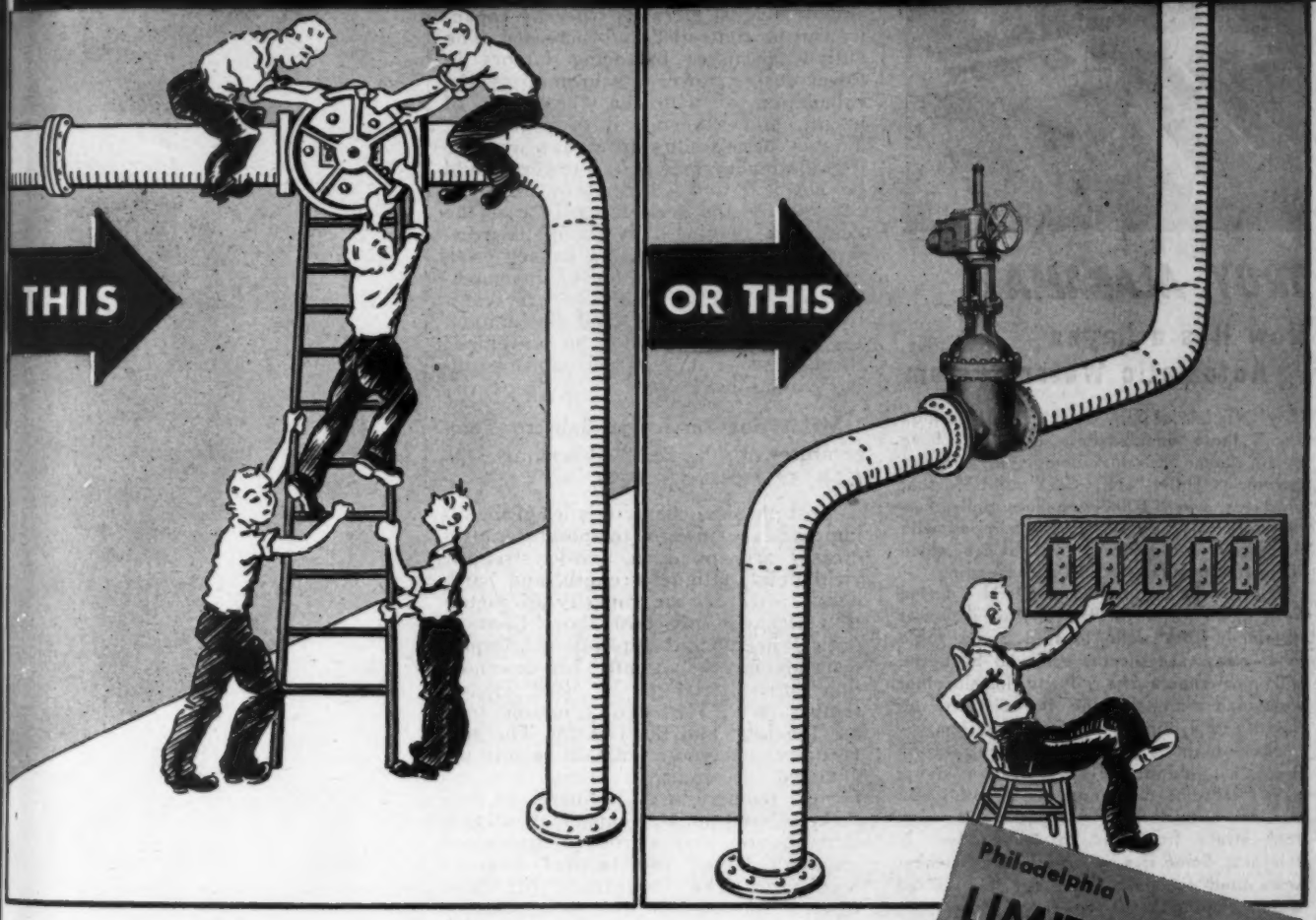

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study the hydrogenation of coal in aqueous alkali at temperatures up to 750° F. and pressure up to 6000 pounds per square inch. A drawing of the autoclave is accompanied by a detailed description and also a photograph.

Capacity Control for Atmospheric Cooling Towers. E. SIMONS. *Chem. & Met. Engr.* **52** (1945) pp. 106-9.

The author states that the purpose of the article is to provide a means of analysis for atmospheric cooling towers and to suggest methods whereby capacity can be controlled and increased. The author discusses balancing factors in tower design, tower psychrometrics, the calculation of a tower, the effect of height, and the control of organisms. To get best results from a tower the distribution system of the tower should be checked and adjusted to give full coverage of the deck areas. In case the decks are sagging they should be reinforced and leveled. Extra capacity can be gained by the addition of intermediate decks in an existent tower. Water treatment is essential, and the amount of treatment should be developed through study of the tower and operating conditions.

Metals for Service at Subzero Temperatures. P. B. BETTY. *Chem. & Met. Engr.* **52** (1945) pp. 102-3.

Most physical characteristics of metals improve at subzero temperatures. Increases are found in tensile strength, yield point, fatigue strength, and hardness. However, the capacity of metals to withstand impact or shock becomes critical in subzero applications. Impact tests are largely accepted for determining the material to be used at low temperature. The two common tests are the Izod and the Charpy. The subzero properties of aluminum remain unchanged or improve from those at normal temperature. Commercially pure nickel shows higher impact at subzero temperatures than at room temperature, although Monel and Inconel drop off somewhat. The importance of nickel in steel for low-temperature application is generally accepted. Most austenitic steels are satisfactory at temperatures as low as —300. All the physical properties of copper and its alloys are retained or improved at subzero temperatures. Commercially pure lead has satisfactory physical properties for —300° F. service. However, not all lead alloys, such as solder, are satisfactory at low temperature.

Petroleum Coke. A. G. V. BERRY AND R. EDGEWORTH-JOHNSTONE. *Ind. & Eng. Chem.* **37** (1945) pp. 551-53.

Secondary cokes are made by pulverizing primary petroleum coke, blending it with 10-20% of asphalt or pitch, and recoking the blend. This is the procedure by which smokeless briquets, electrodes, and similar products are made. The mixture of coke and binder is pressed and molded before the second coking or baking process. Experiments are described in which mixtures of pulverized coke and residuum and cracked asphalt were subjected to secondary coking. For the production of strong, non-porous coke under conditions of rapid heating, two requirements were found necessary: (1) the volatile content

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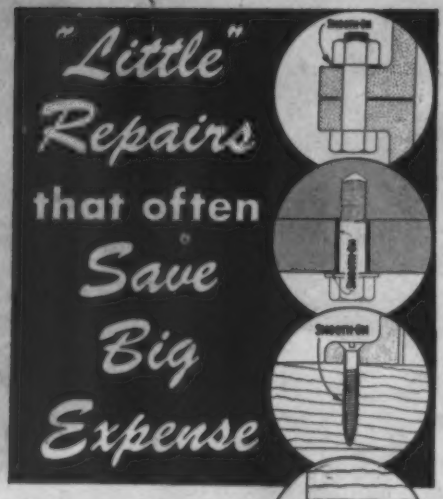

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of the primary coke should exceed 7%; (2) the calculated volatile content of the mixture of coke and binder should not exceed 22%. The data secured are presented in detail in tabular form.

Determination of Aluminum Chloride and Hydrochloric Acid in Hydrocarbon Streams. W. GREEN AND S. R. BAKER. *Ind. & Eng. Chem., Anal. Ed.* 17 (1945) pp. 351-2.

The method described depends upon the fact that when a neutral solution of potassium fluoride is added to an aqueous solution containing aluminum chloride and hydrochloric acid, the aluminum chloride is decomposed into two stable compounds, neutral to phenolphthalein. The free hydrochloric acid can then be titrated with potassium hydroxide. In the absence of potassium fluoride, potassium hydroxide reacts both with the aluminum chloride and the hydrochloric acid. The aluminum chloride is found as the difference between the potassium hydroxide required in a titration without and a titration with potassium fluoride. The apparatus and the method of analysis are described. Duplicate determinations should agree within ± 1.0% providing the iron content is negligible or corrections are made for it. Analyses of known samples and of plant samples are tabulated.

Products: Properties and Utilization

Polythene. Physical and Chemical Properties. F. C. HAHN, M. L. MACHT, AND D. A. FLETCHER. *Ind. & Eng. Chem.* 37 (1945) pp. 526-33.

The term polythene includes a series of polymers of ethylene of various average molecular weights. The present paper is concerned chiefly with polythene of the type and grade developed for electrical use and having an average molecular weight of 18,000 to 20,000. This product is tough and flexible over a wide range of temperatures (including very low ones), is translucent, and is normally white in color. The low electrical losses, along with high resistance to moisture and chemicals and toughness over a wide range of temperature have led to wide use in the electrical field; these properties also suggest many other potential applications. The unusual chemical resistance of the material was studied and the effects of exposure to various chemicals reported. The results indicate applications of polythene to containers, gaskets, tubing, and similar products. The process of flame-spraying the powdered material onto metal surfaces for protection from corrosion is described. Certain flame-sprayed compositions show good adhesion to metals and give excellent protection against corrosion by water, and brine. Data are presented on the physical properties of polythene, such as the relation of density or volume to temperature.

Iron Pentacarbonyl as Antiknock Agent in Alcohol Motor Fuels. I. PITESKY AND R. WIEBE. *Ind. & Eng. Chem.* 37 (1945) pp. 577-79.

In connection with worth on knock suppressors for agricultural motor fuels, the properties of iron pentacarbonyl were investigated. In fuels containing ethyl alcohol, tetraethyllead is not only totally ineffective but actually depresses the octane rating. However, iron pentacarbonyl is an effective antiknock agent for fuels containing alcohol. Caution is necessary in its use, since iron oxide deposits may seriously interfere with engine operation. The action of light changes iron pentacarbonyl to iron enneacarbonyl, which is practically insoluble in hydrocarbon fuels. Iron enneacarbonyl, however, is soluble in ethyl alcohol, and no precipitate occurs. Small quantities of oleic, palmitic, and stearic acids and of triethanolamine oleate are effective stabilizers for the iron pentacarbonyl in some hydrocarbon fuels. For solutions in anhydrous alcohol or ethyl alcohol containing 5% of water, no stabilizer is necessary. Iron pentacarbonyl is probably no more dangerous from a health standpoint than tetraethyllead.

Some Observations on the Mechanism of the Development of Extreme Pressure Lubricating Properties by Reactive Sulphur in Mineral Oils. W. DAVEY. *Jour. Inst. Petr.* 31 (1945) pp. 154-8.

Mineral oils containing free sulphur or active sulphur compounds possess extreme-pressure lubricating properties not shown by straight mineral oils. It has been suggested that the development of these properties is due to the formation of sulphide films on the metal surfaces that prevent metal-to-metal contact. Sulphide films were formed on the surfaces of steel balls subjected to test in the Four-Ball Extreme-Pressure Lubricant Testing Apparatus. E. P. properties were observed using these treated balls, and a straight mineral-oil lubricant, similar to those obtained using untreated balls and an oil-containing reactive sulphur. The friction/time curves obtained using the treated balls show preliminary "sulphur curves" followed by "straight mineral-oil curves" as the sulphide film wears away. The results, although somewhat irregular, offer some confirmation of the "sulphide layer" theory.

Determining the Aromatic Content of Cracked Gasolines by Specific Dispersion. S. GROENNINGS. *Ind. & Eng. Chem., Anal. Ed.* 17 (1945) pp. 361-66.

In determining the aromatic hydrocarbon content of cracked gasolines by specific dispersion, correction must be made for the specific dispersion of the olefins. This correction was calculated from available literature data and found to vary considerably with the class of olefins, with the structure of olefins of any one class, and with the boiling point. An estimate of the reliability of the recommended correction factors is presented; and the acccuracy of the specific dispersion method was determined experimentally. The data secured in the course of the work are presented in some detail in eight tabulations.

Improved Accuracy of C.F.R. Motor Method Test for High Octane Rating with Continuous Scale from 40 to 120 O. N. L. B. SWEETLAND AND P. DRAPER. *Jour. Inst. Petr.* 31 (1945) pp. 105-110.

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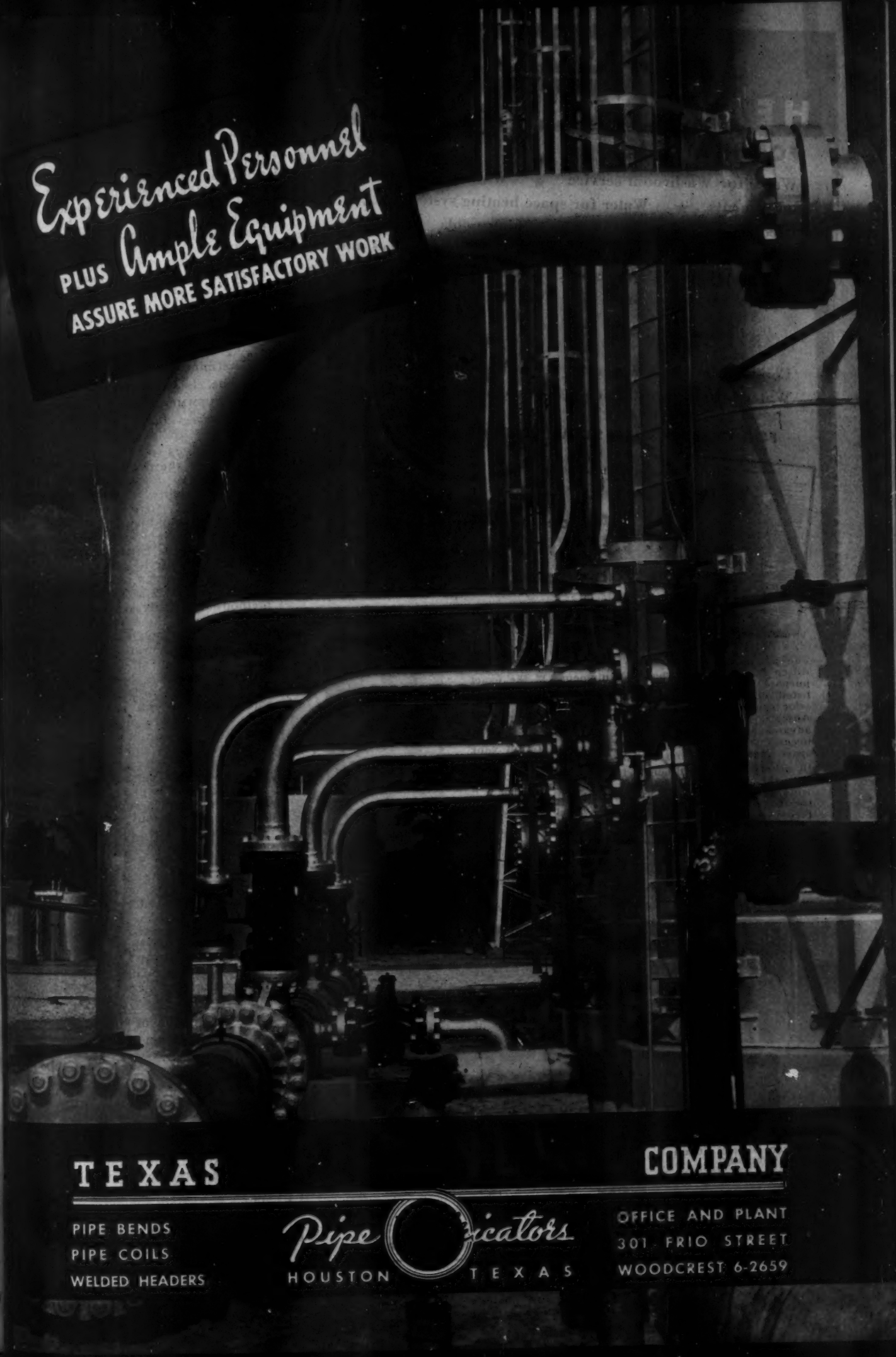
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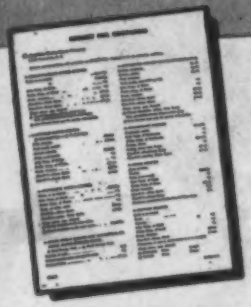

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Method by the A.S.T.M. rendered the 17° method extension of the octane scale non-linear, and prompted the work described in the present paper. It was established that the A.S.T.M. ignition setting at high compression ratios creates unstable conditions of engine operation, with the result that slight fluctuations in spark timing have a marked effect on the knock intensity. The difficulty can be overcome by setting the spark for maximum knock, thus using a lower compression with standard knock intensity. A smooth curve then relates octane number and compression ratio from 40 to 120 octane number. Details of the test are presented. It is recommended that a fixed spark setting of 25° advance be considered for the I.P. and A.S.T.M. Motor Method through the range from 40 to 120 octane number.

Determination of Tetraethyllead in Gasoline. L. LYKKEN, R. S. TRESEDER, F. D. TUEMMLER, AND V. ZAHN. *Ind. & Eng. Chem., Anal. Ed.* **17** (1945) pp. 353-60

The authors note that the various methods for the determination of tetraethyllead have not always been of general applicability to all varieties of leaded fuels, particularly to cracked gasoline, alcohol-blend fuels, and modern motor fuels containing nonhydrocarbon additives. Studies were made of thirteen methods of analysis that were regarded either as outstanding or in common use. As a result of the work two methods of analysis involving direct evaporation of the sample with decomposition agent were chosen because they permit accurate quantitative analysis of lead in all types of gasoline, special motor fuel blends, and tetraethyllead fluid, regardless of the chemical components present. These methods require no elaborate apparatus. In them the lead of tetraethyllead is converted to inorganic lead by mixing with cold hydrochloric acid or iodine, evaporating the resulting mixture to dryness, and removing the organic matter by oxidation with nitric, perchloric, or sulfuric acids, depending on the nature of the decomposition used. The lead in the inorganic residue was determined by precipitating with a measured amount of dichromate solution and determining the excess dichromate by iodometric titration. For commercial gasolines, the reproducibility of the methods is within 0.02 ml. of tetraethyllead per gallon; for commercial tetraethyllead fluids, the reproducibility is 0.4% of lead or better. The methods are described in detail and the results of the work are presented in tabular form.

The Estimation of the Sulphur Content of Petroleum Distillates. A. R. JAVES. *Jour. Inst. Petr.* **31** (1945) pp. 129-53.

A series of investigations was undertaken to ascertain the accuracy of the "lamp method" of test, and to modify the apparatus with a view to obtaining the desired degree of accuracy and sensitivity. As a result of the work a lamp was evolved that will give a rapid and smokeless combustion of samples, including those with a high aromatic content. Particular importance was attached to sulphur contents of less than 0.01% for which the existing volumetric methods were not suitable. The apparatus,

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AS A CLEARER PICTURE of postwar competition emerges, much attention is being given by refiners to the problem of stepping up yields of the most profitable products from reduced crudes.

In this connection, pre-treatment of feed stocks occupies a position in remodernization plans, second only to that of "cat-cracker" installations. For maximum efficiency, two methods are indicated... (1) propane deasphalting and (2) delayed coking —depending upon which residual product can be most readily marketed.

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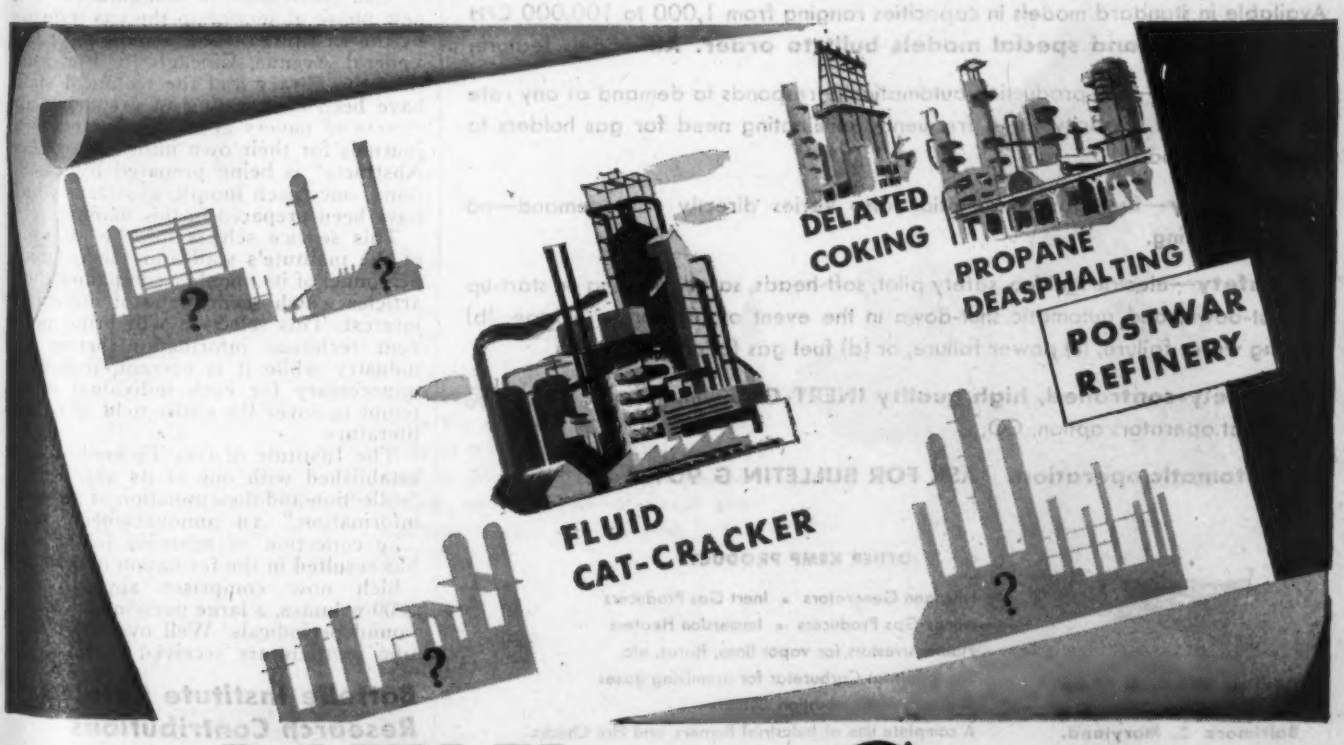

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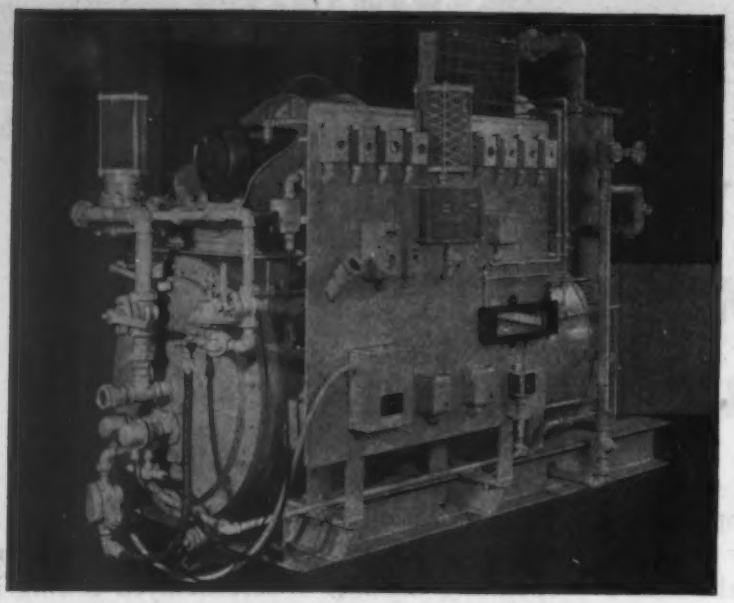

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except for the larger size of lamp, has since been adopted, together with the methods of test, by the Institute of Petroleum, for inclusion as an extra standard method for sulphur determination. The article discusses the reasons for the particular design of lamp and the tests undertaken to ascertain the degree of accuracy obtainable with it. The apparatus is described in detail.

Book Reviews

Adsorption

C. L. Mantell, Chemical Engineering Series, McGraw-Hill Book Company, price $4.50.

In this volume the author has, to quote from his preface, written "from the viewpoint that adsorption is a unit operation of chemical engineering." Theories of adsorption are not but briefly treated in a first chapter but the book has been prepared for the practical engineer, who is concerned with plant operation in processing.

The recent upsurge in catalytic processes in refining make the volume especially timely in petroleum processing. One chapter is devoted to fullers earth and activated clays, while another deals with aluminum-oxide-base materials.

Of special interest to the refining engineers are the chapters on Gas Adsorbent Carbons, Solvent Recovery and Adsorption from Gases, Gas Hydrates and Dehydration of Air and Gases.

Adsorption is available through the book department of Gulf Publishing Company.

Gas Abstracts

"Gas Abstracts" is inauguration of a new phase of service to the gas industry by the Institute of Gas Technology, 3300 Federal Avenue, Chicago 16. For some time the library and the technical staffs have been cooperating in preparing abstracts of papers appearing in technical journals for their own information. "Gas Abstracts" is being prepared by assembling, once each month, abstracts which have been prepared in this manner.

This service selects for the attention of the institute's staff and the technical personnel of its member companies those articles which seem to be of immediate interest. This selection will bring pertinent technical information before the industry while it is current, making it unnecessary for each individual to attempt to cover the entire field of related literature.

The Institute of Gas Technology was established with one of its aims as the "collection and dissemination of scientific information," an announcement says. The collection of scientific information has resulted in the formation of a library which now comprises approximately 5000 volumes, a large portion of which is bound periodicals. Well over 100 scientific journals are received currently.

Battelle Institute Catalogs Research Contributions

A 72-page catalogue of the publications and patents which have resulted from 15 years of fundamental and applied Battelle research has just been published by Battelle Memorial Institute, Columbus, Ohio.

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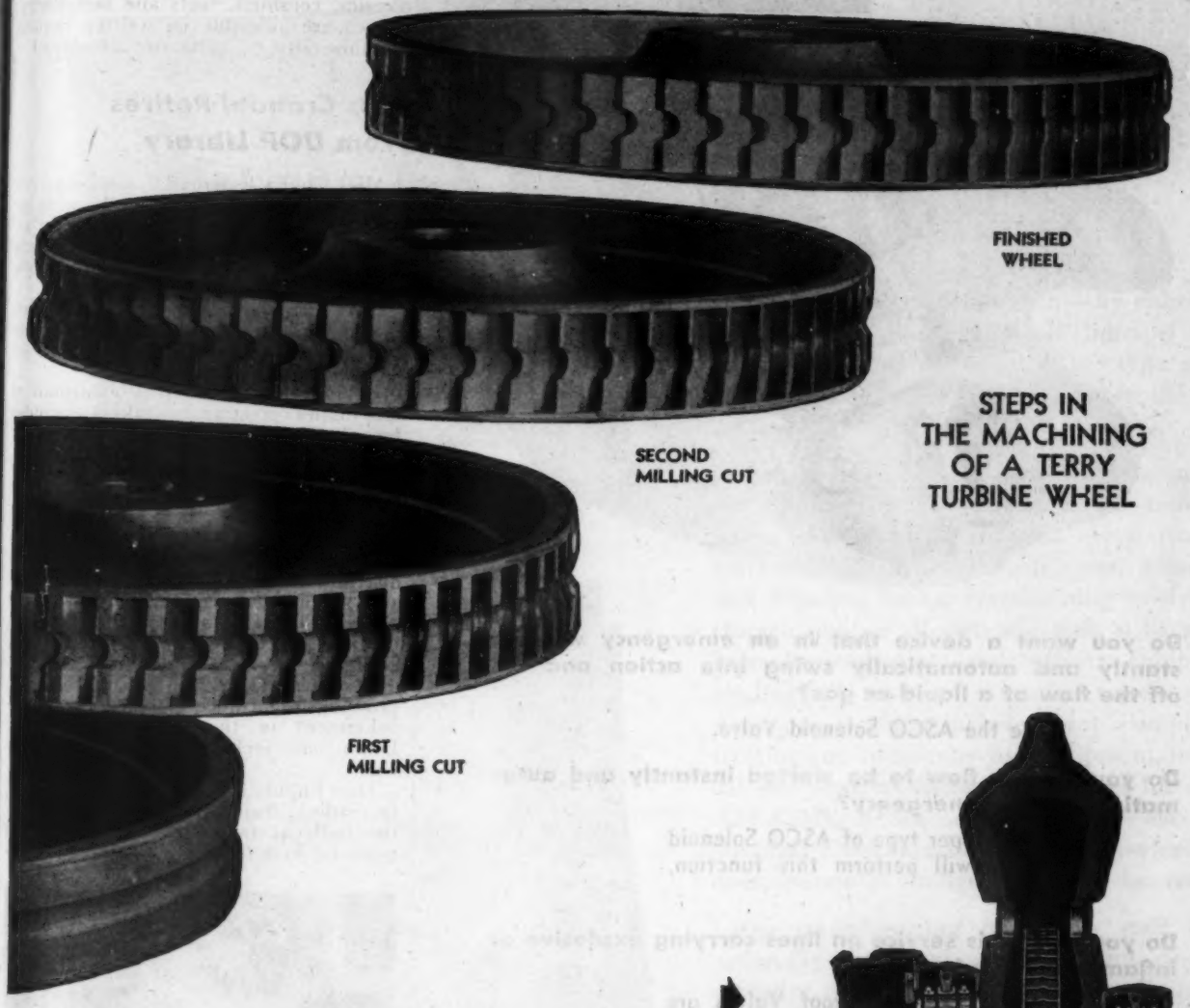

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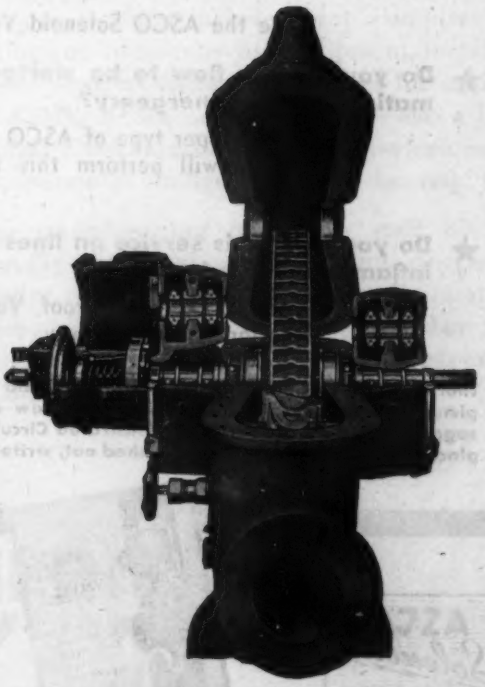

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and industry through research and through the dissemination of technological information, Battelle has published widely in the nation's technical and scientific journals. The new catalogue lists more than 800 such journal contributions, books and patents between the years 1929-1944, inclusive.

The catalogue includes subjects in the fields of organic chemistry, electrochemistry, chemical engineering, graphic arts, welding technology, applied mechanics, mineral dressing, industrial physics, ceramics, fuels and metallurgy. Copies are available on written request on university or company letterhead.

Miss Crandal Retires From UOP Library

Miss Emma E. Crandal, who is known by her works wherever petroleum is refined or studied, was honored by her associates of Universal Oil Products Company, at a testimonial dinner July 13.

Miss Crandal is retiring after 20 years as head of the company's library, over which she has presided since it was established in 1925.

Dr. Gustav Egloff was chairman of the dinner meeting. Speakers included Joseph G. Alther, former vice president; Professor V. N. Ipatieff, and R. E. Day, manager of the Riverside laboratories.

Miss Crandal is best known as the compiler and editor of a weekly bulletin of abstracts, which enjoys worldwide distribution and esteem among scientists and technologists in the petroleum and allied fields. Her scholarly attainments include a knowledge of Latin, French, German and Spanish languages. Moreover a few years ago, recognizing the growing importance of research and development in the Soviet Union, she Union, she tackled and mastered Russian.

Her linguistic abilities are employed in reading, translating and digesting for the bulletin, interesting and important material from leading scientific and tech-

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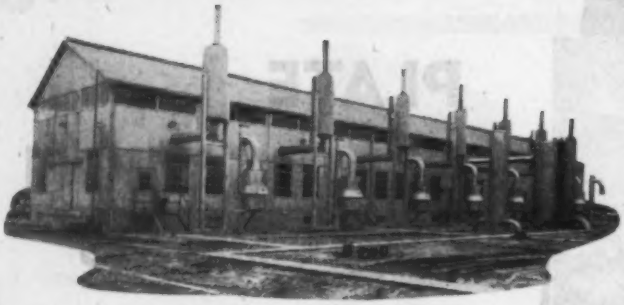

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nical publications. For many years she has been a regular contributor to "Chemical Abstracts," a semi-monthly publication of the American Chemical Society. She is also a member of the Special Libraries Association.

In addition to her editorial work and supervision of the library, Miss Crandal has conducted literature searches upon which much of the activities of the Universal research organization are based.

Graduated from Tri-State Normal College, Angola, Indiana, with an A.B. classical degree, in 1893, Miss Crandal received an A.B. degree in chemistry from Cornell University in 1911.

Curtis Heads American Unit Of English Chemists

Francis J. Curtis, St. Louis, vice president of Monsanto Chemical Company, has been elected chairman of the American Section of the Society of Chemical Industry, an English organization of industrial chemists. He assumed his duties as chairman on July 1, shortly after his return from Europe on a British-American mission to inspect German chemical plants. For the past year he had served as vice chairman of the same committee.

Curtis also is vice chairman of the Division of Industrial and Engineering Chemistry, American Chemical Society, and a director of the American Institute of Chemical Engineers.

China Proposes Using Schoch Acetylene Patent

University of Texas regents have indicated willingness to grant wartime royalty-free use of Dr. E. P. Schoch's electrical discharge process for making acetylene from methane to the Chinese government. The same royalties as charged users in the United States would apply after the war. So far the process, on which Dr. Schoch has been working for several years, is not in commercial use, but is due for early testing in a pilot plant being completed by Commercial Solvents Corporation at Terre Haute, Indiana.

C. D. Shiah of China's Natural Resources Commission recently was in Austin to confer with Dr. Schoch. Shiah said his government proposes to put up a plant to produce acetylene from gas, and then break the acetylene down to alcohol for engine fuel.

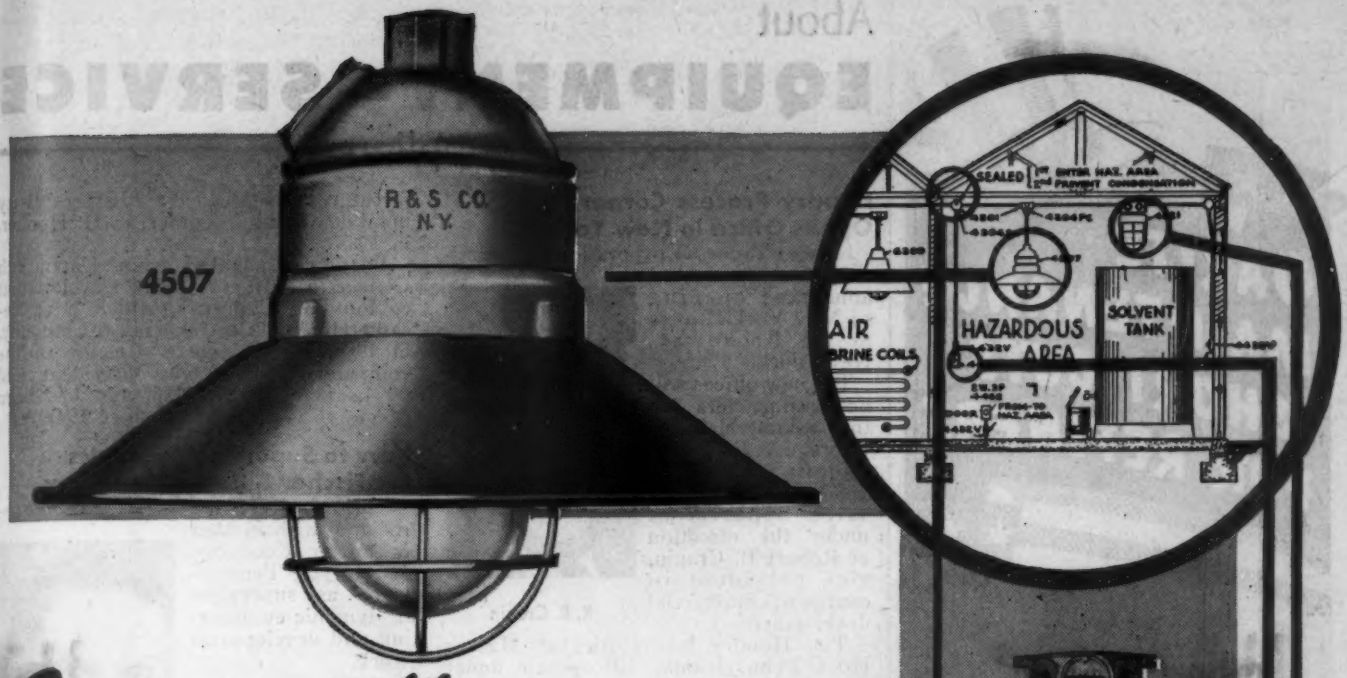
Saueressig Promoted to Administrative Engineer

H. P. Saueressig has been appointed administrative engineer of Southern California Gas Company's butadiene plant at Los Angeles, where he succeeds Dr. C. Gordon Milbourne, who is returning to Ugite Corporation. Saueressig has been staff engineer. Milbourne has been on loan for the past year during construction and early operation of the plant.

Creole Selects Location For Venezuelan Refinery

Creole Petroleum Corporation has selected Turiama, 20 miles east of Puerto Cabello, as the site for a refinery to be built in compliance with the Venezuelan oil law of 1943 requiring foreign oil companies to refine a certain percentage of Venezuelan oil within the country.

Plans include a fluid catalytic cracking unit, and construction is to be completed by the end of 1947.



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About EQUIPMENT—SERVICE Suppliers

Houdry Process Corporation Opens Office in New York

Houdry Process Corporation, Wilmington, Delaware, has announced opening of New York officers at 115 Broadway, New York.

R. B. Cragin

The new offices will be headquarters for the commercial development division, project analysis division and foreign sales department under the direction of Robert B. Cragin, vice president in charge of commercial development.

The Houdry laboratories at Marcus Hook Pennsylvania, will operate under the research and service subsidiary, Houdry Process Corporation of Pennsylvania. Catalyst manufacturing plants are located at Paulsboro, New Jersey.

Slingman Heads Industrial Sales for Baldwin-Hill Company

T. D. Slingman has been appointed manager of industrial sales for Baldwin-Hill Company, Trenton, New Jersey, manufacturers of thermal insulation products. Slingman was formerly vice president of mechanical sales of The Dayton Rubber Manufacturing Company and had previously been associated with Fairbanks, Morse & Company, The Duriron Company and Chicago Pneumatic Tool Company.

T. D. Slingman

Hooker Electrochemical Company Advances Hooker and Bartlett

Harry M. Hooker has been elected chairman of the board of Hooker Electrochemical Company, and has been succeeded by Edwin R. Bartlett as president.

Hooker, a graduate of University of Rochester, has been with the company since 1913, when he served as superintendent of construction. He became sales manager in 1918, and in 1922 was elected vice president in charge of sales and a director. He succeeded to the presidency upon death of his brother, E. H. Hooker, in 1938.

H. M. Hooker

E. R. Bartlett

Bartlett graduated from Dartmouth College in 1904, and joined Development & Funding Company, which later became Hooker Electrochemical Company, in 1907. He became a director of the company in 1925, vice president and works manager in 1935, and has been executive vice president since 1941.

Kerr to Supervise Dynamics For Fischer & Porter Company

S. Logan Kerr recently has become associated with Fischer & Porter Company, Hatboro, Pennsylvania as supervisor of dynamic engineering and development work.

S. Logan Kerr

Following graduation at University of Pennsylvania as a mechanical engineer in 1924, Kerr was hydraulic research engineer for I. P. Morris Company, later absorbed by Baldwin-Southwark Corporation. In 1935 he became senior mechanical engineer for the Passamaquoddy project, and since 1937 has been manager of the chemical engineering division of United Engineers and Constructors, Inc. He holds numerous patents on improvements to hydraulic turbines, valves and speed governors; automatic load and frequency controllers for electrical power systems, and on chemical apparatus.

McLaughlin Sales Manager for Pittsburgh Gas Products Division

W. R. McLaughlin has been appointed sales manager for the gas products division of Pittsburgh Equitable Meter Company, and will have headquarters at Pittsburgh. In his new position he will direct sales of meters, regulators, and allied equipment for measurement and control.

W. R. McLaughlin

McLaughlin started his business career with Arkansas Natural Gas Company in 1919, his work there being largely devoted to gas-distribution and transmission activities which involved measurement and regulation, and he was superintendent of the gas-measurement division for the company from 1928 until he left in 1934 to join Pittsburgh Equitable Meter Company as sales engineer in the Southwest.

McLaughlin has been active in the work of the Southwestern Gas Measurement Short Course at the University of Oklahoma, having served on committees throughout the 22 years of his course, and was general chariman in 1934. He also has served at various times on the

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gas-meter committee of American Gas Association, and the gas-measurement committee of American Petroleum Institute. He was one of a committee of eight selected from industry to assist the faculty of Texas College of Arts and Industries, Kingsville, in establishing a course in natural-gas engineering. For this participation he was awarded an honorary degree in natural-gas engineering by the college in 1938.

Ord General Manager of Sales For Monsanto Organic Division

Robinson Ord has been appointed general manager of sales of the organic division of Monsanto Chemical Company. Formerly an assistant general manager of sales, Ord succeeds Fred C. Renner, who died June 26.

Arthur P. Kroeger has been appointed an assistant general manager of organic division sales, and Charles H. Sommer, Jr., has been assigned responsibility for sales of intermediates as well as plasticizers and resins.

Ord is a graduate of Oxford University's Pembroke College from which he received a B. A. degree in 1929. Starting with Monsanto as a trainee in 1929, he served successively as correspondent, export manager, assistant manager of sales and, since 1941, assistant general manager of sales.

Kroeger, formerly in charge of sales of intermediates, graduated from the University of Akron with a B. S. degree in 1931. He entered Monsanto employ in 1929 as a technical salesman in the rubber service division. After a period of service abroad as a technical salesman, he was stationed at San Francisco and later was branch manager at Los Angeles. Since 1941 he has been in charge of sales of intermediates at St. Louis headquarters.

Sommer attended the Universities of Michigan and of Arizona, graduating from the latter with the degree of B. S. in 1933. He has been with Monsanto since 1934, and since 1939 has been in charge of sales of plasticizers and resins for the organic division.

Robinson Ord

A. P. Kroeger

Feldbush Heads Engineering Activities for Worthington

Harry A. Feldbush, formerly works manager of the Holyoke, Massachusetts plant of Worthington Pump and Machinery Corporation, has been named vice-president in charge of engineering for the corporation. His duties cover engineering activities of all works and domestic subsidiary companies. His headquarters will be at the general offices in Harrison, New Jersey.

Ralph M. Watson, formerly chief engineer of the centrifugal engineering division, has been appointed assistant to Feldbush.

D. A. Sillers Becomes President Peerless Manufacturing Company

D. A. Sillers has resigned as superintendent of gas measurement for Lone Star Gas Company, to become president of Peerless Manufacturing Company, 3015 Main Street, Dallas 1, Texas.

D. A. Sillers

Sillers is a graduate of Carnegie Institute of Technology, and spent four years as sales engineer with The Foxboro Company before joining Lone Star Gas Company 20 years ago. During these years he developed the gravity balance, recording gravitometer, orifice meter slide rule, and a gas cleaner in general use in the industry. He also has developed the products of Peerless Manufacturing Company, which include separators for gas and oil, steam and air; natural gas odorizers, and a valve for shutting down pumping wells. He has been active in the development of present gas-measurement practices, and will be available as a consulting engineer on gas-measurement problems.

Cooper Alloy Foundry Announces Refinery Equipment Department

The Cooper Alloy Foundry Company, Hillside, New Jersey, has announced establishment of a department which will specialize in heat-resisting stainless castings. This service will be in conjunction with the company's representative, Duffee Engineering Service, 504 Stuart Street, Houston 6, which involves the personal attention of P. Y. Duffee in engineering, application and production of return bends and headers.

Pitts Heads Refinery Sales For Oil Well Supply Company

Allen F. Pitts has been advanced to manager of refinery sales for Oil Well Supply Company, and will continue to make headquarters at Dallas. He will be assisted by Walter Williams, district engineer for the refinery division of the company at Houston.

Allen F. Pitts

Pitts started with Oil Well Supply Company in Oklahoma in 1917, and has served in Kansas, Wyoming and Texas. In various important positions related to materials and inventories for the company since 1930, he moved from Tulsa to Dallas in 1932. In his new assignment he will develop a program to provide increased participation by the company in the sale of products used by refineries and related industries for all domestic divisions.

Other recent announcements of changes in assignment of sales personnel of Oil Well Supply Company include:

Paul H. Shepherd, formerly assistant division manager at Fort Worth, has been made Midwest divisional manager with supervision of the Coastal area comprising South and Southwest Texas,

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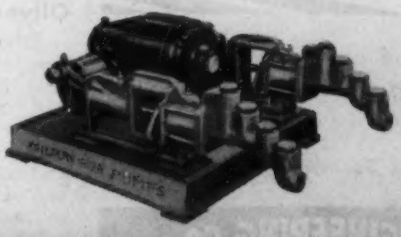

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Texas and Louisiana Gulf and Mississippi. His headquarters will be at Houston.

Howell P. Fogle, formerly district manager at San Antonio, has been appointed division tubular representative with headquarters at Houston, and is replaced at San Antonio by W. P. Clements, Jr., transfered from Western Canada.

Don L. Collins, formerly manager of machinery sales at Oklahoma City, has been made manager of machinery sales for the Midwest division, at Houston.

Carl C. Egner, formerly assistant division manager at Houston, has been named manager of pipe-line equipment sales, at Dallas.

D. O. Smith, formerly district engineer at Evansville, Indiana, has been appointed training section supervisor of the general sales department at Dallas.

Charles A. Butcher Joins Crocker-Wheeler

Charles A. Butcher, formerly manager of the Pacific Coast manufacturing and repair department of the Westinghouse Electric Corporation, Oakland, California, has been appointed assistant general manager of Crocker-Wheeler Division, Joshua Hendy Iron Works, Ampere, New Jersey. A fellow member of the American Institute of Electrical Engineers, Butcher is the author of several articles on automatic controls for power generation and on sub-station and distribution equipment. He is also the inventor of a number of devices and control systems related to automatic switch gear.

C. A. Butcher

Following his early electrical experience with Des Moines City Railway Company, he joined Westinghouse and was employed, successively, in Chicago district sales, East Pittsburgh, design engineering and general engineering. Subsequently he held the following positions with Westinghouse: Eastern district engineering Manager and Eastern district service manager, New York; manager of Eastern manufacturing and repair department at Newark, New Jersey; assistant manager of manufacturing and repair department, East Pittsburgh; and manager of Pacific Coast manufacturing and repair department. He graduated from Iowa State College with the degree of B.S. in electrical engineering.

Welty Heads Fastener Sales for Oliver Iron and Steel Corporation

Edward M. Welty has been named general manager of sales of the industrial fasteners division of Oliver Iron and Steel Corporation. He succeeds James G. Graham. Welty joined the organization in Pittsburgh 34 years ago and was sent to Philadelphia as a member of the sales staff. He was advanced to manager of the Philadelphia office before returning to Pittsburgh. In July, 1942, he went to Washington as chief of the bolt and nut, screw and screw machine products division of WPB. On January 1, 1944, he returned to Pittsburgh to become assistant general manager of the sales division he now heads.

J. E. Gesner Again With Reliance Regulator Corporation

J. E. Gesner recently rejoined Reliance Regulator Corporation, division of American Meter Company, as engineer. His experience includes 15 years with the Pacific Gas & Electric Company, where he started in the East Bay division, from which he was advanced to the Colgate division as measurement inspector. He later became industrial gas engineer of the general sales department. His scholastic background includes Polytechnic College of Engineering, Oakland, California, and the University of California.

J. E. Gesner

Foote Mineral Company Makes Personnel Changes

Dr. Edgar Pitzer, formerly head of the inorganic research group, has been named director of research for Foote Mineral Company, Philadelphia. Before joining the company last February, Dr. Pitzer for several years was a research engineer with Standard Oil Company of New Jersey, with American Zirconium Corporation on mineralogical research, and with Catalyst Research Corporation in high-vacuum pyrotechnic investigation.

W. F. Luckenbach, Jr., formerly director of research, has been named development engineer for the company. He has had experience with synthetic organics and unusual compounds of lithium, strontium and zirconium products, especially in connection with petroleum, rubber and allied industries.

V. Dale Martin has joined Foote Mineral Company as sales coordinator. He holds degrees in mining engineering from University of Kansas. Until recently he was in charge of the export division of the sales and research staff of Wright Aeronautical Corporation.

Carborundum Company Names Two District Managers

The Carborundum Company, Niagara Falls, New York, has announced appointment of William H. Homeyer and Francis J. Blake as district sales managers. Both have been industrial salesmen for the company on the Pacific Coast.

Homeyer, with headquarters at Los Angeles, is in charge of the Southern California sales area, and Blake will cover Northern California from San Francisco.

Pittsburgh-Merco Nordstrom Export Organization Formed

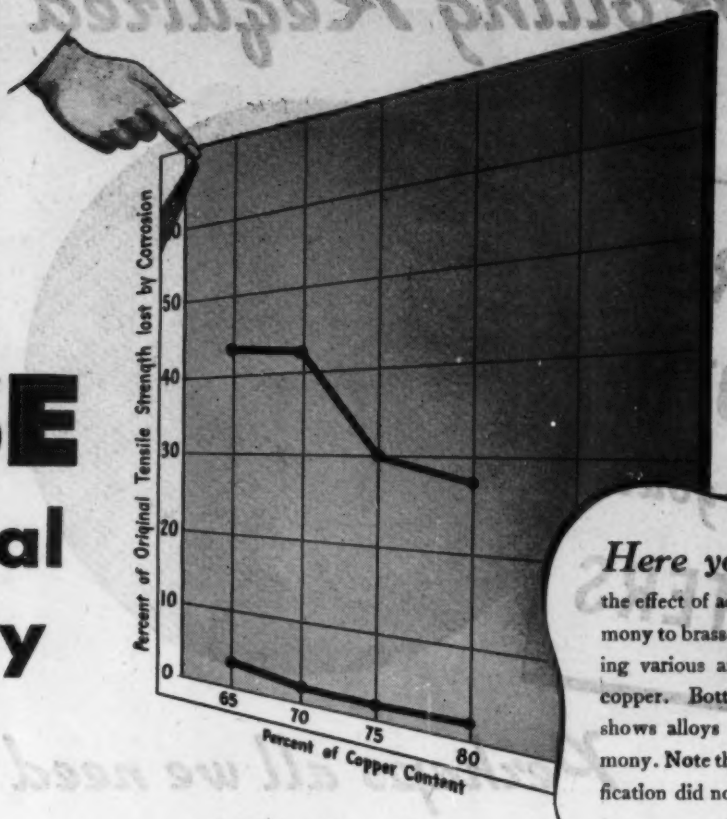
Pittsburgh International Corporation has been formed to handle export sale and distribution of products manufactured by Pittsburgh Equitable Meter Company-Merco Nordstrom Valve Company and subsidiaries. Offices are to be opened September 1 at 7701 Empire State Building, New York, under direction of A. L. DiGiulian, vice president. He will be assisted by George E. Doty.

DiGiulian has spent many years in government service, and recently has been chief of the foreign communications section of the office of exports of the Foreign Economic Administration at Washington. He has had extensive ex-

Get greater resistance to dezincification

with

CHASE Antimonial Admiralty



Here you see the effect of adding antimony to brasses containing various amounts of copper. Bottom curve shows alloys with antimony. Note that dezincification did not occur.

...and cut your yearly condenser tube costs!

YOU can reduce condenser tube replacement costs substantially with Chase Antimonial Admiralty.* The combination of antimony with Admiralty metal increases resistance to dezincification, and that of course means longer condenser tube life, fewer tube replacements.

10 YEAR PERFORMANCE RECORD

Since 1935, *millions* of pounds of this Chase copper alloy have been installed, yet not a single service failure has been reported from dezincification.

You might expect to pay more for such a tube, but the initial cost of Chase Antimonial Admiralty Tubes is no greater than for plain Admiralty. And think what you save annually in *replacement* costs!

3 POINTS TO REMEMBER

These are points to keep in mind concerning Chase Antimonial Admiralty Tubes

- Extraordinarily resistant to dezincification
- Virtually immune to inter-crystalline corrosion
- Costs no more than plain Admiralty

For complete information, phone your nearest Chase Warehouse or Sales Office.

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No Rolling Required

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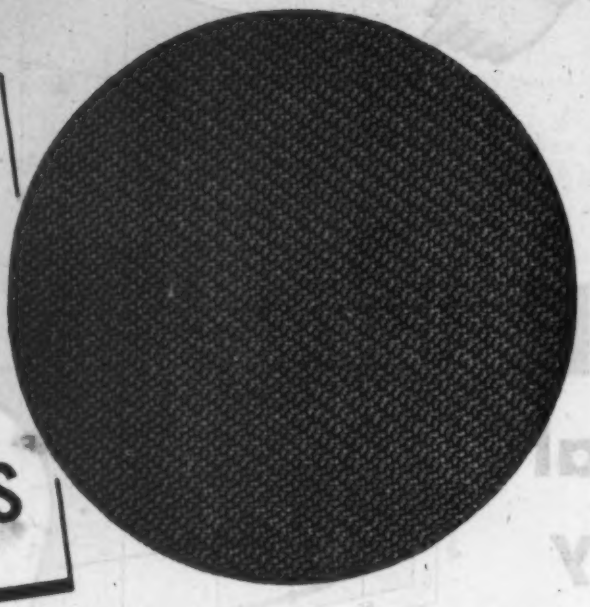

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FOR YEARS, we've been making wire cloth for use on standard refinery pressure filters. Woven firmly and uniformly from carefully selected and annealed wire, NEWARK cloth is free from looseness and waviness. It requires no rolling to make it lie flat and snug in the filter—a factor enhancing its durability.

Metals available for your requirements include stainless steel, Monel and nickel. We can provide *any* mesh up to 100 x 1000.

Why not try NEWARK the next time you buy wire cloth?

NEWARK *for* ACCURACY

NEWARK WIRE CLOTH COMPANY

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8-AWC-2

perience in foreign markets and is an accomplished linguist. He was educated in Europe, completing studies in Italy, Spain and Portugal, and was graduated from Georgetown University's school of foreign service in 1927.

Doty joined Pittsburgh Equitable Meter Company in 1926, after attending Carnegie Institute of Technology. His experience embraces all phases of manufacture and sale of the company's products, and before the war he served as export manager. More recently he was assigned to the Merco Nordstrom Valve Division at its Oakland, California, plant as assistant to the general manager.

Patterson Sales Engineer For Detroit Diesel at Tulsa

C. W. Patterson has been appointed sales engineer for Detroit Diesel Engine Division, General Motors Corporation. He will make headquarters at Tulsa, on the staff of Arch F. Campbell, manager of General Motors Corporation's petroleum industry sales department.

C. W. Patterson

Patterson has been with Detroit Diesel Engine Division's engineering department for several years, and since 1942 has been a special service representative in the South Pacific. He was assigned to the amphibian engineers, where his specific duty was to supervise maintenance of General Motors diesel engines in battle zones. He and his associates often assisted in setting up service stations in the jungles of New Guinea and in bridgeheads on other South Sea islands, thus assisting in keeping diesel-powered landing craft always available for action.

Ethyl Corporation Regroups National Sales Organization

Ethyl Corporation has announced reorganization of its sales department field operations on the basis of four principal marketing areas with a sales manager appointed for each area.

The four area sales managers named are Richard C. Murphy, for New England and Middle Atlantic states as far south as South Carolina; James E. Boudreau, for the Mid-Continent area; Harold R. Berg, South; and Sanford M. Wagner, for west of the Rockies.

The sales manager of each area will be responsible for services extended to all customers in the area and will supervise sales activities of the divisions within his territory. Under the plan, the divisions within the four marketing areas are as follows: Eastern area—New York and Philadelphia divisions; Central area: Kansas City, Chicago and Dayton divisions; Southern area: Tulsa and Atlanta divisions; Western area: Los Angeles and Seattle divisions.

In addition to the four area sales managers, George Krieger has been named to the new post of special assistant to Julian J. Frey, general sales manager, to coordinate customer programs affecting more than one of the four principal areas and to supervise certain services on a national basis.

Donald S. Flynn, formerly assistant manager of the Kansas City division,

This stainless steel "Cat Cracker" equipment illustrates but one of many applications for Republic ENDURO in the modern refinery.

Enduro Pays in many ways

High resistance to corrosion—an inherent quality of stainless steel—is one of the most important requirements in the selection of a material for refinery equipment applications in which operating conditions prohibit the use of less resistant materials.

Proof that Republic ENDURO Stainless Steel lengthens equipment life in severe service is found in the fact that many leading refineries are using this versatile metal for valves, pumps, tanks, tubing, condenser shells and still linings.

And because ENDURO possesses an extremely high strength-to-weight ratio—even at high temperatures—it can be used in thin, light-weight sections without sacrifice of strength or safety.

There are many other reasons, too, why it will pay you to specify ENDURO Stainless Steel. For complete information, write to:

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A BETTER Strainer to "police your pipelines"

- **FIRST**—*The Screen*, a high-grade woven Monel wire basket that catches solids—lets condensate, oil or other fluids flow freely.
- **SECOND**—*Finish*. Cadmium plated inside and out for protection against corrosion.
- **THIRD**—*Easily Cleaned*. Blow-off bushing made for easy removal. Bushing and Screen come out together. Screen automatically aligns on reassembly.
- **THOUSANDS IN SERVICE**—Sold by over 100 Mill Supply Houses.

6 sizes from ½" to 2" for pressures up to 600 lb. Reasonably priced. See your supply house or write for Bulletin S-200.

YARNALL-WARING COMPANY
128 Mermaid Ave. PHILADELPHIA 18, PA.

has been appointed manager of the division to succeed Berg, Southern sales manager. Wagner will retain, for the present, his position as manager of the Los Angeles division while serving as Western sales manager.

Matthew A. Taylor, former manager of the Boston office, has been appointed manager of the new division in Philadelphia. The services formerly rendered by the Boston office have been transferred to the New York division.

Although designed as a postwar measure, it is announced, the reorganization is effective immediately to enable the corporation to take preliminary steps giving the maximum amount of service and assistance to customers in their readjustment of operations from a war to a peacetime basis.

Ohlson Senior Chemical Engineer For Pennsylvania Salt Company

John E. Ohlson has been appointed senior chemical engineer for Pennsylvania Salt Manufacturing Company, Philadelphia.

Ohlson received a master's degree in engineering at University of Michigan in 1934. Recently he has been assistant to the manager of plant operations for Wyeth, Inc., at Philadelphia, and before that was process engineer with Niacet Chemicals Corporation at Niagara Falls, New York.

Oliver Iron and Steel Appoints Export Sales Manager

Oliver Iron and Steel Corporation announces appointment of David H. Scott as export sales manager. Scott for the past four years has been a steel buyer for the British purchasing commission and has had wide experience in the steel-export field. He has been associated with Carnegie-Illinois Steel Corporation, the Steel Export Association of America, and Jones and Laughlin Steel Corporation. He will maintain headquarters at 50 Church Street, New York.

Minneapolis-Honeywell Promotes H. E. Chapler

Appointment of H. E. Chapler as sales manager of the oil controls division of Minneapolis-Honeywell Regulator Company has been announced. His headquarters will be in New York, but he will direct sales to oil-equipment manufacturers throughout the United States.

Thompson Export Sales Manager For Oliver United Filters

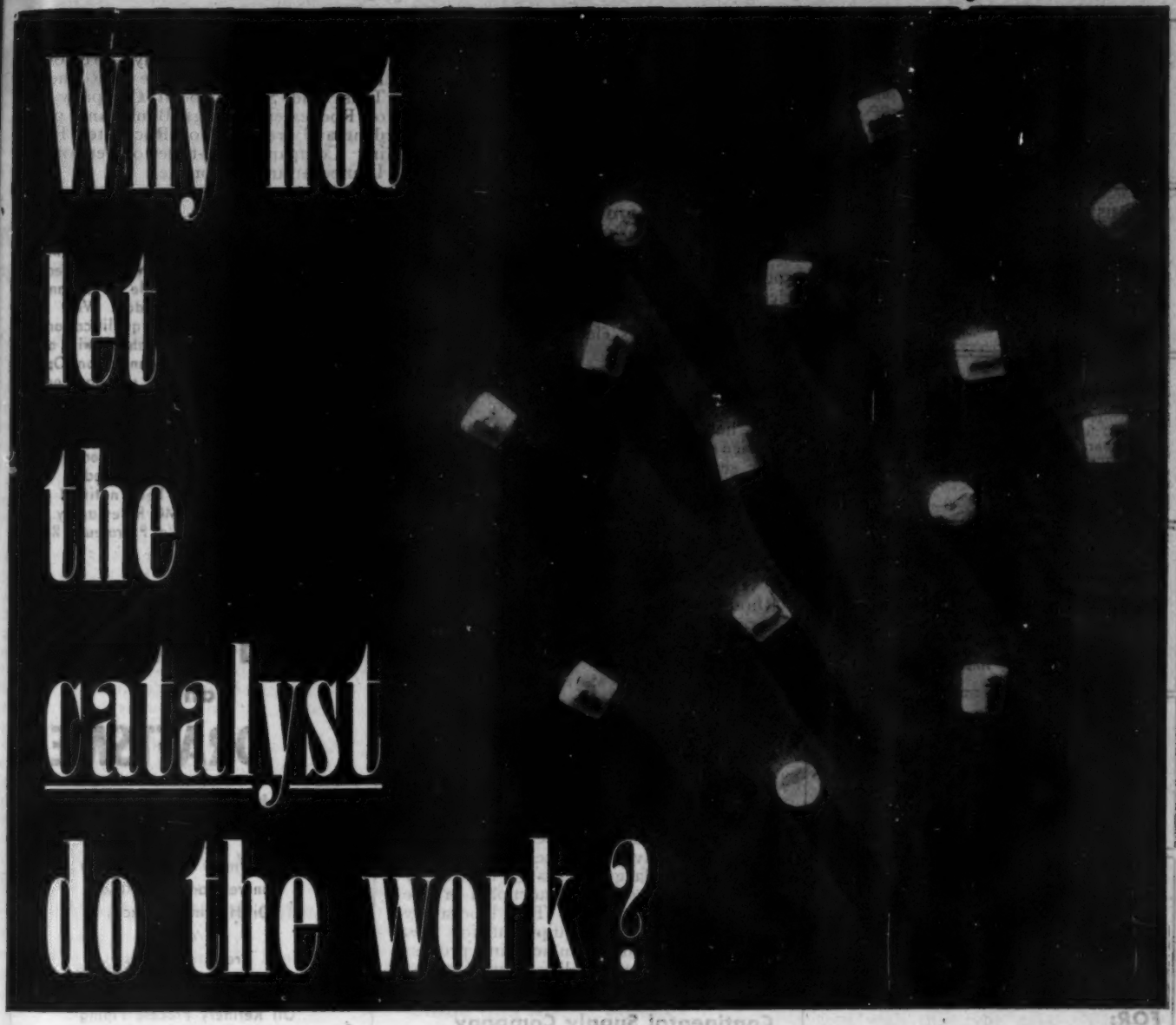
Leon D. Thompson has been appointed export sales manager for Oliver United Filters, Inc., with offices at the company's New York headquarters, 33 West 42nd Street (18). Thompson is a mechanical engineering graduate of Stevens Institute of Technology, and has been with the company as a technical filtration engineer for more than 25 years.

McManigal Vice President of Westinghouse International

Robert D. McManigal has been elected vice president of Westinghouse Electric International Company. He has been manager of the company's Associated Companies Department since 1940, with offices in New York.

He joined Westinghouse Electric Corporation at Pittsburgh in 1915 and in 1922 went to Japan as an engineer for Westinghouse Electric International

Why not let the catalyst do the work?



In catalytic cracking, maximum catalyst activity produces optimum yield of gasoline—maximum profits. This is another of many advantages enjoyed by Houdry licensees. For Houdry and TCC units maintain the highest equilibrium catalyst activity of all catalytic units.

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Houdry Catalytic Processes and the TCC Process are available through the following authorized firms:

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HOUDRY CATALYTIC PROCESSES
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MECHANICAL ENGINEER WANTED or man with suitable equivalent to inspect physical equipment in chemical plant located in metropolitan Detroit. Must be familiar with pressure vessels, piping, etc. Permanent position. Salary up to $350 monthly for 48 hour week depending on education and experience. Write giving full details to **Box 89, c/o Petroleum Refiner,** Houston, Texas.

CHEMIST OR CHEMICAL ENGINEER, experienced in petroleum refinery operations and pilot plant procedures; capable of correlating yield data, preparing reports, and guiding the progress of pilot plant operations; for a major engineering company in New York City. Address: **Box 59, c/o The Oil Weekly,** Houston, Texas.

PROCESS ENGINEERS, with experience in design of petroleum processing units such as thermal or catalytic cracking plants, or gas plants, stabilizers and absorbers; for a major engineering company in New York City. Address: **Box 58, c/o Petroleum Refiner,** Houston, Texas.

REFINERY PROCESS ENGINEERS having from two to five years experience in preparation of calculations for design or control of fluid catalyst cracking, alkylation, or light ends fractionation processes. Growing Refinery technical organization offers excellent opportunities for advancement to capable engineers. MUST COMPLY WITH W.M.C. REGULATIONS. Address: Box 78, c/o Petroleum Refiner, Houston, Texas.

Centrifugal Pump Engineer able to take charge of design of pumps for refinery use. Record of experience should be submitted. Address: Box 70, c/o Petroleum Refiner, Houston, Texas.

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Company. He served as managing director of the Westinghouse Electric Company of Japan until that firm's dissolution in 1931. Since then he has been, successively, manager of the Central Station-Transportation Apparatus Department, assistant to the vice president, and manager of the Associated Companies Department.

Hammett Becomes Sales Manager For A. M. Lockett & Company

George R. Hammett has been appointed manager of sales of the New Orleans district office of A. M. Lockett & Company, Ltd., to succeed R. P. Lockett who recently was elected vice president of the company.

Hammett has been with the company since his graduation from the Engineering School of Tulane University in 1918, and has specialized in application and service engineering of refinery equipment. For several years he has been assistant manager of sales in the New Orleans office.

Proportioneers Opens Office in Mexico City

%Proportioneers, Inc.%, Providence, Rhode Island, has appointed %Dosificadores Y Valvulas, S. A.%, Dolores No. 16, Mexico, D. F., to represent the company in that territory. The new organization, headed by Mariano Lara and Manuel Garcia Sands, includes a factory-trained engineering staff and offers complete sales and engineering facilities to handle proportioning problems.

Keasbey & Mattison Company Using Larger Laboratory

Keasbey & Mattison Company, Ambler, Pennsylvania, recently formally opened its enlarged research laboratory which has more than quadrupled in size during the past year. The laboratory contains the latest equipment for new product research, manufacturing process improvement and quality control of asbestos and magnesia products.

Continental Supply Company Elects F. M. Mayer President

Effective July 1 William J. Morris became chairman of the board of directors of The Continental Supply Company, a newly created office. As such he will be the chief executive officer of the company. Frederick M. Mayer succeeded Morris as president. Frank I. Brinegar was elected executive vice president and also a director.

R-S Products Names Philadelphia Distributor

R-S Products Corporation has appointed Fluid Controls Company, 18 West Chelton Avenue, Philadelphia, distributor of its valves in Eastern Pennsylvania, Southern New Jersey, and Delaware.

Herbert J. Winn Dead

Herbert J. Winn, chairman of the board of Taylor Instrument Companies, died at Rochester, New York, June 27. He would have been 75 on July 12. He started with the company in 1893, and in 1898 went to London to open a branch office. Returning to this country in 1905, he assumed much of the responsibility of management of the company, and in 1913, upon the death of J. Merton Taylor, was made president, continuing as such until 1938, when he became chairman of the board. His activities outside Taylor Instrument Companies included chairman of Lincoln-Alliance Bank and Trust Company, director of Pfaudler Company, trustee of Rochester Trust and Safe Deposit Company and of Rochester Savings Bank, and president and treasurer of Rochester Printing Company, one-time owner of the Democrat and Chronicle.

Independent refiner, transporter, and marketer with refinery in south, marine equipment on Mississippi River and Great Lakes, terminals in Middle West and marketing interests in Middle West is looking for young men with qualifications and a strong desire to get ahead with an energetic, independent organization. Opportunities as tankerman, stillman, operator, dispatcher, terminal operator, filling station supervisor and others.

Write advising as to age, education, experience, marital status, compensation paid in past and what is expected.

Our employees have been notified of this advertisement. WMC Rules apply.

Address Box 707 c/o Petroleum Refiner, Houston, Texas.

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Must have experience in design of:

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Pressure Vessels

Can also use a qualified checker on Oil Refinery Process Piping

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Tulsa, Oklahoma

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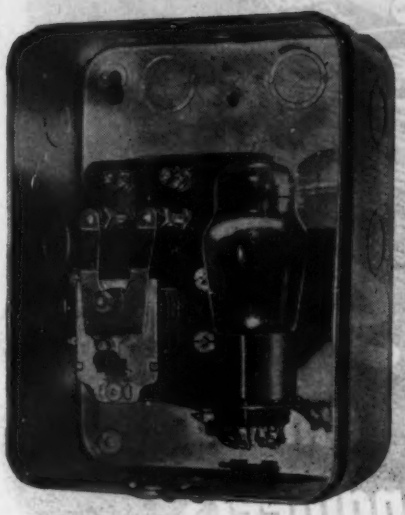
FOR FREE COPIES OF MANUFACTURERS' LITERATURE OR MORE INFORMATION ON PRODUCTS DESCRIBED ON THESE PAGES, USE THE MAILING CARD INSERTED IN THIS ISSUE

1—Electronic Relay

Precision Thermometer & Instrument Company, 1434 Brandywine Street, Philadelphia, is manufacturing a super-sensitive electronic relay, a grid-controlled, half-wave rectifier that combines in one compact unit all the functions of a series of relays such as are commonly employed for control of outputs up to 30 amperes, 110 to 120 volts, 50-60 cycle, A. C. up to 30 amperes are controlled with only 100 microamperes in the instrument circuit. No audible A. C. hum. Low-resistance, "fine" silver contacts are easily adjusted or replaced. Coils are precision wound, impregnated and baked, and must withstand a breakdown test far in excess of rated capacity. Standard vacuum-tube amplification, and simplicity of design and wiring, assure maximum service life.

Originally developed for use with mercurial thermostats and thermoregulators, these relays are used in a wide variety of industrial and laboratory control applications with such instruments as contact microammeters, pressurestats, photoelectric cells and similar apparatus.



"Princo" Electronic Relay

2—"Karbate" Flexible Couplings

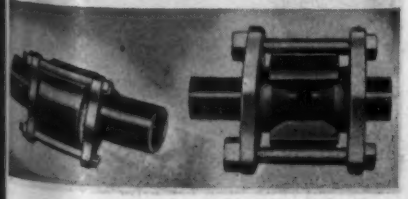
National Carbon Company, 30 East 42nd Street, New York 17, has announced perfection of four new flexible "Karbate" pipe connections for use in chemical and process industries. These connections are made of impervious carbon or graphite, and possess mechanical strength and resistance to thermal shock and corrosive liquids and gases characteristic of all "Karbate" specialty products, it was said.

The Type FC flexible coupling is particularly suited to field installations or any pipe run connecting one phase of the process with another, as it eliminates cements in joining lengths of pipe. The FC coupling permits sufficient pipe movement to meet all conditions encountered in the average plant.

Type V flanged connections offer advantages of the Van Stone type of flanges. Thickness and sturdiness of the small diameter collars provide a construction which may be used with companion flanges of almost any design or material. Separate cast-iron split flanges permit easy pipe alignment and installation.

Type V nozzles and Type SC slotted couplers now available usually are factory-installed, and are particularly recommended for use on tanks, towers, heat exchangers and similar equipment.

The four new flexible "Karbate" connections are designed to meet the widest range of pipe requirements throughout the process and chemical industries.



Type FC "Karbate" flexible coupling

3—Globe and Angle Valves

The Ludlow Valve Manufacturing Company, Troy, New York, has added a line of cast steel globe and angle valves in sizes 2 to 6 inches, inclusive. These valves are sturdy, well proportioned and streamlined for maximum flow with minimum pressure loss. Ratings are 150 pounds per square inch oil working pressure, at 500° F. in 150-pound line; 300 pounds oil working pressure at 800° F. in 300-pound line.

A new slip-proof malleable iron hand wheel provides added strength. Heavy substantial metal sections in the valve body and unusually large diameter stems, to resist heavy stresses, assure trouble-free life. The valves may be repacked under pressure, and all are equipped with regrindable discs and renewable seat rings.

Ludlow Valve

The class C trim especially designed for oil and oil vapor service uses a chrome steel seat ring and ball type disc to cut through heavy viscous oil and seat tightly.

The valves comply with or exceed API and ASA standards as to material, design, temperature and pressure ratings.

4—Welding Electrode

Westinghouse Electric Corporation, Box 868, Pittsburgh 30, has announced a new ACP electrode for speedy and economical welding in all positions, and with A-C and D-C reverse polarity. It is available in seven diameters from 5/16- to 3/32-inch.

This new heavily coated electrode, recommended for high-quality welds on work which is not easily positioned, forms a light, porous slag which is easily removed from each pass by light brushing. Because of high tensile strength and ductility of welds, this rod is especially suited for heavy-plate fabrication, pressure piping, pressure vessels, and general structural-steel work.

Easy to handle on vertical and overhead work, ACP produces excellent results in making horizontal fillet welds and lap joints on all low- and medium-carbon steels, as well as low-alloy and cast steels. It meets various association code requirements.

5—Ionization Gauge

Precision Scientific Company, 1750 North Springfield Avenue, Chicago, announces the "Precision-Televac" ultra-vacuum gauge, Type E-31, of which it says:

"Type E-31 is the result of years of research to eliminate deficiencies usually associated with this type gauge. Electrical leakage is eliminated, and when used with a moderately high speed pumping system, this ionization gauge actually outgasses itself. Filament is protected before and during operation automatically in that current will not enter filament before pressure of 1 micron has been established, and turns off auto-

Ionization Gauge

—another reprint just completed . . . get your free copy now!

Yes, the same Wilson Tube Cleaners Check-List that found such wide acceptance in its original edition, has just been reprinted—and it's available to you for the asking.

This six-page folder gives valuable hints on tube cleaner maintenance and operation that will show you how to save wear and tear on your tube cleaning equipment. These suggestions will go a long way toward making your present equipment last longer and give better service. Moreover, there is a two-page Tube Cleaner Selection Guide that will help you choose the right Wilson Tube Cleaning Motor, Cutter Head and accessory to get your job done faster and more efficiently with minimum damage to tube walls.

Your copy of the Wilson Tube Cleaners Check-List will be sent on request—and without obligation, of course.

Modern tube-cleaners for the problems of today.

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For copies of manufacturers' literature or additional information on products described, use mailing card, at page 249.

matically if pressure rises above 1 micron. Gauges are interchangeable without recalibration and guaranteed for 1000 hours. Standard E-31 ionization gauge comes on scale at 0.4 micron (4×10^{-4} MM Hg). The ionization gauge is used with the Televac Type S recorder."

A new bulletin, 450R, illustrates and describes the complete line of "Precision-Televac" high-vacuum instruments.

6—Extinguisher Trigger

Walter Kidde & Company, 140 Cedar Street, New York 6, says in an announcement that the trigger control which has distinguished smaller sizes of Kidde carbon-dioxide fire extinguishers has been extended to larger portable models. Operated with one hand, the new model is controlled by a pull of the index finger, the largest extinguisher requiring approximately the same trigger force as the smallest. It can be latched open when desired, and easily disengaged to avoid wasting gas.

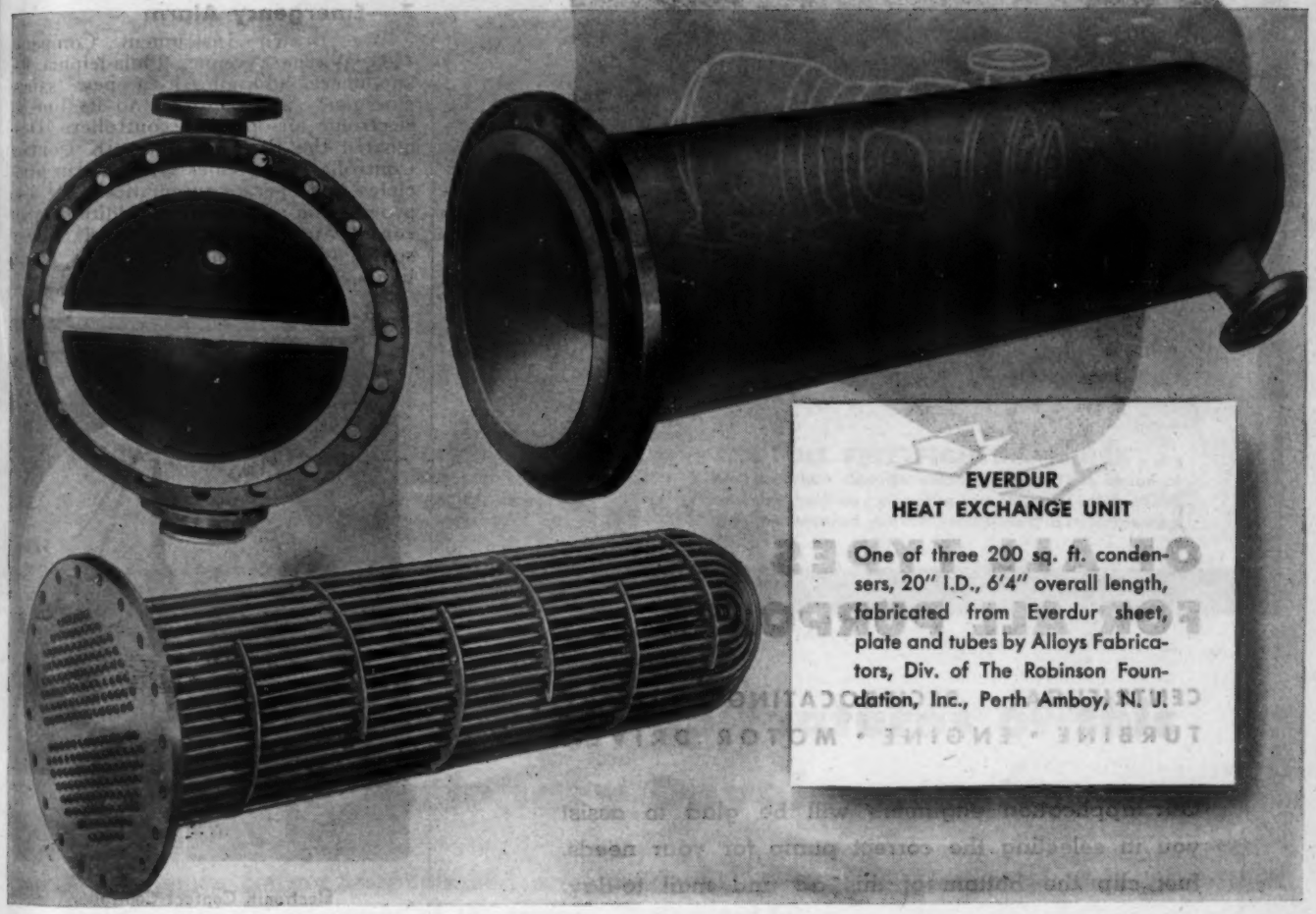
This control is the result of many years of engineering research, it was said. The objects were to provide an on-and-off control of discharge with a minimum of effort; to permit a high rate of flow of the carbon dioxide, avoiding directional changes in its passage in so far as possible; to allow easy locking-open with one hand; and to incorporate these features in a small, compact part, relatively light in weight and simple in design. These objects have been accomplished. There is only one directional change in the valve passage, avoiding loss of force and giving a full flow directly to the nozzle.

The one-piece handle closure protects the valve itself, is light in weight and fits the hand comfortably. Other improved features of the extinguisher as a whole are the permanent bushing and removable siphon tube, which allow inspection, periodic hydrostatic testing and, when necessary replacement of any part, without devalving.

The locking pin fits into a blind hole

Kidde Trigger Control

Built of Everdur . . . to withstand HOT CORROSIVE VAPORS



EVERDUR HEAT EXCHANGE UNIT

One of three 200 sq. ft. condensers, 20" I.D., 6'4" overall length, fabricated from Everdur sheet, plate and tubes by Alloys Fabricators, Div. of The Robinson Foundation, Inc., Perth Amboy, N. J.

This two-pass heat exchange unit is a good example of thorough workmanship and sturdy, corrosion-resistant construction of Everdur*. Used for condensing hot vapors in the manufacture of synthetic rubber, it is one of three such units built by Alloys Fabricators, Div. of The Robinson Foundation, Inc., Perth Amboy, N. J.

The shell and removable head were formed from 3/16" thick Everdur sheet. The shell was carbon-arc welded with rods of Everdur 1010. Everdur plate 7/8" thick was used for the tube sheet, the tubes being 3/4" by .065" gage Everdur.

This same tough, corrosion-resistant copper-silicon alloy was also employed for the baffle plates, and for pipe connections on shell and head.

For condenser tubes and other parts of heat exchange equipment subjected to heat and corrosion, Everdur Metal is but one of a number of Anaconda Copper-base Alloys which provide long, economical service under widely varying conditions. For detailed information, write for Publication B-2.

*Reg. U. S. Pat. Off. 45132

THE AMERICAN BRASS COMPANY
General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Company
In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

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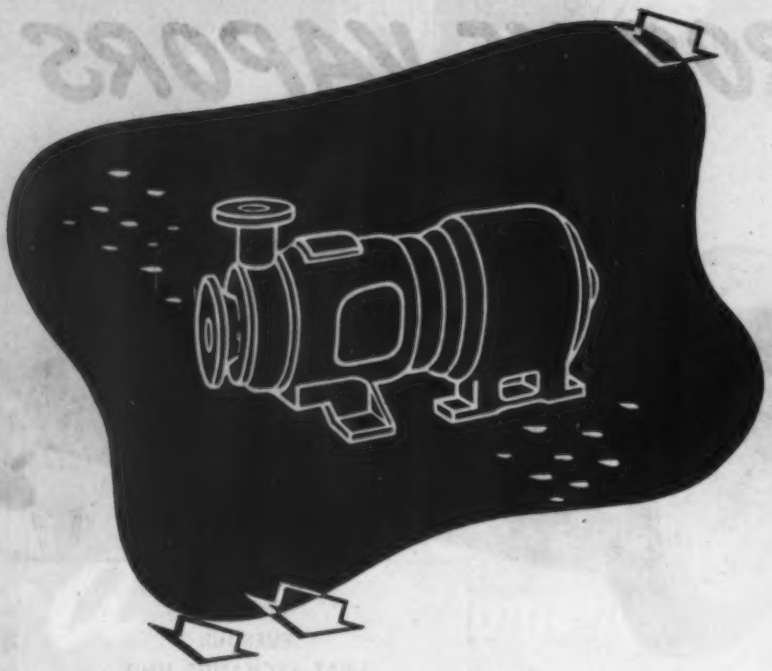
Everdur Copper-Silicon Alloy

Pumps



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Equitable EQUIPMENT COMPANY, INC.

410 CAMP STREET • NEW ORLEANS, LA.

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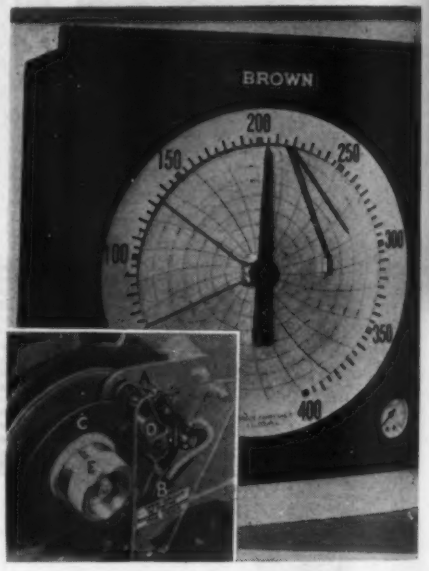
so that there is no possibility of its getting bent and jamming, and the seal wire is placed where it is least likely to be broken, and most easily observed.

The extinguisher is carried and operated with one hand, leaving the other free to manipulate the discharge nozzle.

7—Emergency Alarm

The Brown Instrument Company, 4498 Wayne Avenue, Philadelphia 44, announces addition of a new safety emergency alarm feature to its line of electronic air-operated controllers. Designated the Brown ElectroniK Contact Controller, it provides safety alarm principles that operate automatically. It also provides on-off control in addition to air control to actuate motorized valves, solenoid valves, contactor panels, signal lights, etc.



ElectroniK Contact Controller

As shown in the picture of the ElectroniK and the contact controller, contacts A and B are made or broken by the action of cam C and roller D, and the spring-loaded lever to which it is attached. The control point is set by loosening the knurled knob E and rotating cam C so that its notch corresponds to the position of the temperature pen that has been previously moved to the desired point. The pen position sounds the emergency alarm. A red pointer on the scale, not shown in the picture, indicates the temperature setting of the contact controller.

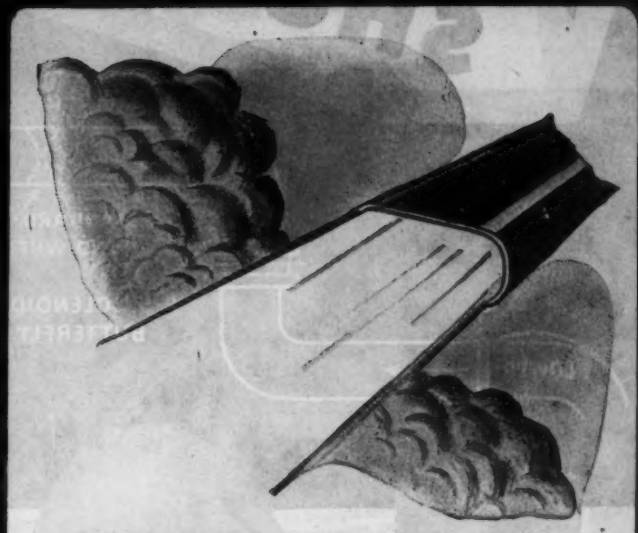
8—Steel Fittings

Ladish Drop Forge Company, Cudahy, Wisconsin, has added a new line of forged steel fittings, available in carbon, alloy and stainless steel, and designed for high-pressure piping from 2000 to 6000 pounds.

Available in sizes from ⅛-inch through 4 inches, the line includes a wide variety of both screwed and socket welding fittings, including 90-degree elbow, tee, 45-degree elbow, cross, street elbow and lateral types. Also offered is a line of steel couplings and reducers, steel bush-

Announcing TRIGGER-FINGER Control for 10, 15, and 20-lb. fire-fighters

AT THE PULL OF A SINGLE FINGER... the new valve on these larger sizes of Kidde portable extinguishers opens with the same ease that has long been a popular feature of the 2- and 4-pound sizes.



THE FULL FIRE-FIGHTING FORCE . . . of the carbon dioxide discharge goes into action at once—no half-way measures with this new valve. When trigger is released, shut-off is complete and instantaneous.

And here are the PLUS features of this Revolutionary Development

1. Lock-open control is simple and sure. A slight forward movement of the trigger finger latches trigger open—no danger of fouling.

2. No replacement parts are needed for recharging.

3. Hydrostatic testing can be carried out without devalving. No devalving for repairs either.

4. Recoil outlet is of improved design.

5. Balanced handle design and low center of gravity make it easier to carry these bigger sizes of extinguishers.

6. Intermittent or continuous control is provided for.

7. The locking pin *cannot jam*. It seats in blind holes—there are no projecting ends to get bent over.

8. Streamlined design improves appearance.

9. Seal wire is fully visible for quick inspection.

10. Valve design is simple, fool-proof. The natural way's the right way to operate it—even a novice can't make a mistake!

10-, 15- and 20-pound extinguishers equipped with this new valve will be ready for delivery October 1. Place your order now.

The word "Kidde" and the Kidde seal are trade-marks of Walter Kidde & Company, Inc.

Walter Kidde & Company, Inc. • 140 Cedar Street • New York 6, N. Y.

No. 628
Should current fail or blower stop, R-S Solenoid Valve installed on hot gas line closes immediately.

The R-S Solenoid Trip Valve is used for emergency service. The solenoid can be arranged with the counterweight mechanism to open or close the valve and hold it there in one position or the other. If for any reason the solenoid functions, the latch is tripped, which permits the counterweight to open or close the valve by gravity. The assembly is suited to shut off the flow or to open a vent and requires manual reset. Can be constructed of any metal or alloy and in various sizes for air, gases, steam, oil, hydraulic and other services.

State your requirements and ask for Catalog No. 14-B.

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15 to 900 psi, for air, gas, steam, liquids and semi-solids.

R-S Streamlined BUTTERFLY VALVES

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ings and steel half couplings, caps and plugs, with pressure ratings corresponding to the ratings of the fittings up to 6000 pounds.

The screwed fittings have full depth, accurately cut thread, which allows easy entry of the pipe and results in pressure-tight joints. Deep sockets of the socket welding fittings speed up installation by saving time formerly spent in cutting pipe to exact length.

9—Melamine

American Cyanamid Company, 30 Rockefeller Plaza, New York 20, has published a 24-page illustrated booklet describing applications of melamine. In color and designed for popular appeal, the booklet supplements technical data which has been published on applications of melamine and the chemical compounds in which it is used. Among the more important applications mentioned are its use in plastics of high arc resistance; in wet-strength paper; in the shrinkage control of wool; in making improved leather; in water repellents for fabrics; in improved enamels suited to mass production of automobiles and household appliances, and in the production of the chemical equivalent of distilled water.

10—Rotameter

Fischer & Porter Company, 9207-0 County Line Road, Hatboro, Pennsylvania, has issued Catalog 43-E, on armored rotameters for measuring and controlling flow rates at high pressures and temperatures. It includes illustrated descriptions and engineering data on many designs of indicating and recording instruments.

11—Evaporative Coolers

Worthington Pump and Machinery Corporation, Harrison, New Jersey, is distributing Bulletin C-1100-B27, on evaporative coolers. Diagrams and tables give engineering details.

12—Refrigeration Compressors

Worthington Pump and Machinery Corporation, Harrison, New Jersey, has issued three new bulletins on refrigeration compressors: Bulletin C-1100-B21, on gas engine refrigeration compressors; Bulletin C-1100-B22, on steam-engine-driven horizontal double-acting refrigeration compressors ,and Bulletin C-1100-B23, on horizontal double-acting booster refrigeration compressors.

13—Electronics

Allis-Chalmers Manufacturing Company, Milwaukee 1, has announced availability of a 20-page booklet, E 6358, "Introduction to Electronics," an educational bulletin prepared by Dr. Walther Richter of the company's engineering development division.

A brief discussion on the fundamentals of conversion and control of electric power in a load prefaces introduction of the subject of electron tubes. Approaching this subject as a guide for application engineers, instead of tube designers, the book explains that the electron tube is a new control element which is noth-

COPPER ALLOY BULLETIN

MARINE AND POWER EDITION

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared by Bridgeport Brass Company — "Bridgeport" brass on — *Headquarters for BRASS, BRONZE, and COPPER*

Arsenic as a Corrosion Inhibitor

Destroying the Myth of Intercrystalline Attack

The use of arsenic as a dezincification inhibitor for Admiralty condenser tubing and 70-30 brass was reported as far back as 1924 by the well-known metallurgists, Bengough and May in the British Institute of Metals as part of the Seventh Report to the Corrosion Research Committee of the Institute of Metals (British). This discovery attracted world-wide attention because of their masterly work on the mechanics of dezincification and methods of preventing it. Aside from arsenic they also found that "tin, nickel, tungsten, antimony and aluminum all had the same kind of effect as arsenic but less intense and in the order named."

As a result, arsenic which they considered the most effective inhibitor of dezincification is now added in amounts up to 0.04 percent to brass condenser tubing as standard practice by British manufacturers. It was also adopted as standard practice by Bridgeport Brass Company and most of the larger American manufacturers about 1936. These investigators also developed aluminum brass for condenser tubes and included arsenic as an inhibitor.

Recently, investigations by two American manufacturers indicated that antimony and phosphorus are corrosion inhibitors. In obtaining their U. S. patents for adding these other dezincification inhibitors, the inventors claimed that their inhibitors are superior to arsenic because they prevent the occurrence of "intercrystalline attack" which they stated is characteristic of brasses containing small amounts of arsenic added intentionally to prevent dezincification. Their claims were based on accelerated corrosion tests which were conducted with solutions of several concentrations of cupric chloride. No experiments under actual service conditions, as found in seaboard power plants, marine condensers, heat exchangers and oil refineries, were conducted to substantiate any of their claims.

In recent months we have come across rumors to the effect that Arsenical Admiralty is subject to "intercrystalline attack" and naturally we wish to run them down. In Bridgeport Brass Company's long experience, as well as in the experience of other companies who have been manufacturing arsenical Admiralty condenser tubes for many years, no evidence of the mythical "intercrystalline attack" has been found. Several laboratory investigators, using cupric chloride as the attacking agent, have reported the development of intergranular cracking in both Arsenical Admiralty and plain Admiralty.

Recently we checked with a prominent authority as to British practice and experience and received the following:

"The beneficial effect of small amounts of arsenic in brass in preventing dezincification of the alloy has been widely known for many years. In this country it is, and has been for several years, quite a common practice to add arsenic to the extent of about 0.02—0.04 percent not only to aluminum brass, but to other brass alloys for the manufacture of condenser tubes.

"We are not acquainted with any evidence arising either in the course of experiments or in service which would indicate that the presence of this amount of arsenic is in any way injurious or detrimental to the alloy, or that it gives rise to any kind of intercrystalline failure."

Regardless of the use of other corrosion inhibitors besides arsenic which are being advocated by some manufacturers, Bridgeport Brass Company intends to continue to supply Arsenical Admiralty, Arsenical Muntz, and Arsenical Aluminum Brass because experience has shown that the addition of arsenic is excellent as a dezincification inhibitor. We have yet to run across a single case of intercrystalline attack and would appreciate it if our friends will help us spike the rumor or bring the offender out in the open where we can all take a good look at it, if it is in existence.

Cupro Nickel Now Released For General Use

It has been announced that limitation order L-154 schedule II which restricted the use of cupro nickel tubes in steam surface condensers has been revoked, and that cupro nickel is now available for general use.

70-30 cupro nickel condenser tubing made to Navy specifications 44T39a, is the standard alloy specified by the U. S. Navy for all battleships and many other types of vessels. Besides excellent resistance to impingement attack, this alloy withstands erosion and corrosion in most cases better than brass. It was adopted by the Navy after numerous tests indicated that Admiralty condenser tubing could not stand up satisfactorily for fast steam turbine-propelled vessels which depend on condensers that produce a high vacuum and operate with high water velocities. Under such conditions tubing is exposed to both corrosion and erosion caused by the impingement of air bubbles associated with water of high velocity and turbulence. 70-30 cupro nickel made to Navy specifications 44T39a fulfills the requirements of the U. S. Bureau of Ships which calls for the presence of 0.6 maximum percent iron and over 0.5 percent manganese.

70-30 cupro nickel withstands elevated temperatures better than brass and is used for feed water heaters, heat exchangers and evaporators where good corrosion resistance is imperative. This alloy is said to be immune to season or stress corrosion cracking caused by the combined action of moist ammonia, oxygen, stress and time. Since cupro nickel has a lower specific thermal conductivity than brass, some designers of condensers provide 10 percent additional condensing surface as compared to brass tubes, to allow a safe margin for this difference. However, there are engineers who claim that the thermal conductivity has little bearing on the rate of heat flow from one fluid to another through such a metal wall.

Because this alloy has superior properties to most metals and alloys, cupro nickel is being carefully considered for many applications involving corrosion too severe for ordinary metals. This is in line with the present tendency to fight the ravages of corrosion with better materials which may be higher in first cost, but which are most economical when length of service and reduction in maintenance are taken into account.

Note: Bridgeport products are supplied in accordance with existing priority regulations.

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Table model electric stop clock with a-c clutch and toggle switch

ACCURATE INSTRUMENTS for PRECISION TIMING

The Stoelting table model electric stop clock is an accurate timer for a wide variety of industrial and laboratory tests . . . such as measuring start-to-stop intervals of relays and instruments, and for checking sequence operations.

Timer with a-c clutch has toggle switch for manually starting the pointer. Timer with d-c clutch has binding posts only for attaching d-c control circuit for starting and stopping the pointer. Both timers have a-c clock motors, and pointers are reset with knob.

The Stoelting electric timer and impulse counter is an accurate, dual-purpose instrument for counting individual electric impulses or for use as a chronoscope.

When used as timer, 11-16 v current is taken from step-down transformer. When used as counter, direct current only is used. Counter capacity—7,200 impulses.

FREE ILLUSTRATED BULLETIN

Send for Stoelting Timer Bulletin No. 1100. Includes illustrations, wiring diagrams, technical data, and complete information on stop clocks, chronoscopes, impulse counters, stop watch controllers, and X-ray timers.

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We KNOW the construction and service problems involved and HOW best to solve them. If you are contemplating the purchase of such equipment, consult with us NOW. It will facilitate earliest possible erection as soon as materials are available.

The STACEY BROTHERS GAS CONSTRUCTION CO.
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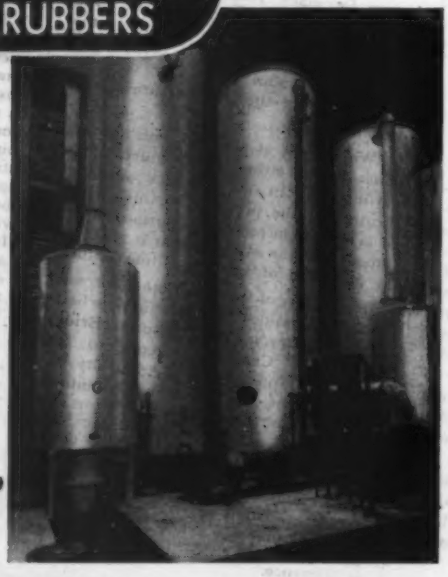
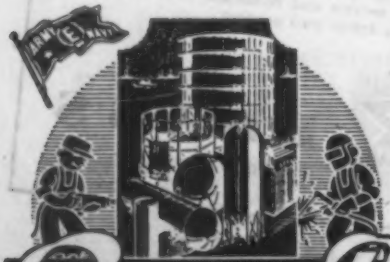


Photo above shows a group of Stacey Brothers primary and secondary condensers and scrubbers installed in a gas plant.



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ERECTORS • RECOGNIZED
EXPERIENCE & FACILITIES

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ing but a special type of rheostat or switch. The discussion of tubes is divided into two main parts: vacuum and gaseous.

Differences between a vacuum tube and the equivalent mechanical device, methods of specifying tube performance, application of tube characteristics for design purposes, and use of the high speed response of the tube are explained. Clearly presented are principles of tube detector action with applications, and principles of tube oscillators with application to induction and dielectric heating. Line drawings, curves, and sketches add materially to comprehension.

14—Electrical Products

Wagner Electric Corporation, 6384 Plymouth Avenue, St. Louis 14, has issued a 16-page folder (Form GU-86) describing briefly its line of electrical and automotive products: motors, transformers, industrial brakes and controls, hydraulic brakes, air brakes, tachographs, brake lining, and brake-service tools.

15—Corrosion-Resistant Materials and Equipment

The U. S. Stoneware Company, Tallmadge Circle, Akron, Ohio, recently has issued Bulletin H which briefly describes many corrosion-resistant materials and equipment now available from this manufacturer, including tank linings, towers and tower packings, and chemical stoneware.

16—Equipment Inspection

Engineering Laboratories, Inc., 602 East Fourth Street, Tulsa, has available a booklet, "The Story of the Penetron," which contains data on instrument for measuring density, thickness and other characteristics of materials by means of reflected gamma rays. Developed by Texaco Development Corporation, this instrument has particular adaptation in refineries for use in determining internal corrosion and erosion of pipes and vessels without dismantling or boring.

17—Packings

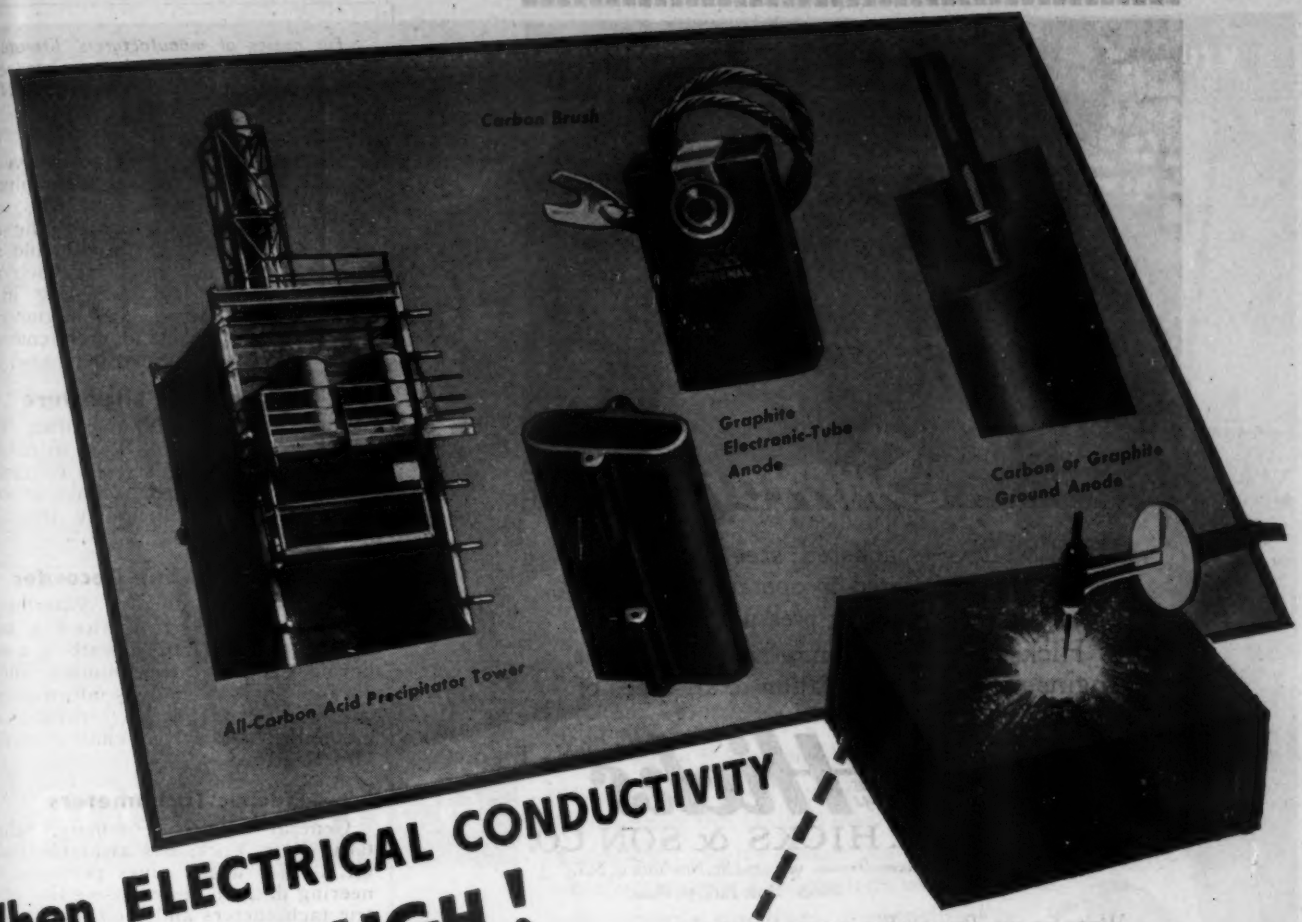
Greene, Tweed & Company, Bronx Boulevard at 238th Street, New York 66, is distributing Bulletin P-3, a pocket-size folder which is a handy guide for selection of packing for specific fluids, equipment, and types of service.

18—Welding Chart

Arcos Corporation, 1515 Locust Street, Philadelphia 2, is inviting requests for a new and simplified reference chart on alloy welding electrodes. The data, which are grouped for quick reference, includes weld metal chemical analyses; information on corrosion resistance, on heat resistance, and on weld metal surfacing. It also includes welding currents and voltages and stub and color table.

19—Centrifugal Pumps

The Deming Company, Salem, Ohio, is distributing an illustrated booklet titled "Facts You Should Know About Centrifugal Pumps and Impellers," which is a description of centrifugal



When ELECTRICAL CONDUCTIVITY Isn't ENOUGH!

BESIDES electrical conductivity, each of these devices must have certain other properties . . . in combinations found only in carbon or graphite!

Because of these properties, the 46-foot carbon precipitator withstands acids and thermal shock. The mechanically strong carbon brush minimizes arcing and operates at lower friction than other materials. The graphite electronic tube anode dissipates heat, retains its shape and is inert. And the ground anode resists chemical and electrolytic action in the cathodic protection of metal structures.

"National" carbon and graphite can be supplied in grades running from porous to impervious . . . widely known in the latter form as "Karbate" materials and products.

We've specialized for 60 years in manufacturing many grades of carbon and graphite and applying their singular properties to the solution of industrial problems. For more information write for our Catalog Section M-8000-A.

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DIGESTER — jacketed, steel, with screw conveyors engineered to operate at 300 lbs per square inch working pressure.

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3. Ease of application.
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8. Will not deteriorate.
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10. Low cost per sq. ft. in place.

Thermostic No. 2 Thermal Insulating Cement is shipped in dry form. It is easily stored, there is no danger of breakage and it does not deteriorate. Mixing and applying is a simple process requiring no special tools.

Thermostic No. 2 is a most efficient insulator up to 1800°F and where temperature does not exceed 1200°F, can be removed, mixed with water and reused.

Write for information on the properties which make Thermostic so valuable as an insulator.

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pumps and the principles involved. It was written primarily for the company's salesmen and distributors, who, as it explains, cannot all be hydraulic engineers. Consequently it is valuable reading for those who operate such units without having had schooling in hydraulics, and should aid engineers in directing operation and maintenance of these units by untrained personnel.

20—Engineering Literature

Allis-Chalmers Manufacturing Company, 565, Milwaukee 1, is distributing a directory of products and engineering literature describing the lines of equipment it furnishes, including 1600 product types.

21—Running-Time Recorder

The Bristol Company, Waterbury 91, Connecticut, has published a folder, Bulletin No. OP1502, describing a newly developed machine running-time recorder. The folder gives information regarding principle of operation and method of use. Typical chart records are illustrated.

22—Electric Tachometers

General Electric Company, Schenectady, New York, has available Bulletin GEA-4324, which gives pertinent engineering data on an extensive line of electric tachometers and their application to measurement of speed of varied moving units.

23—Chemicals from Coal

Koppers Company, Tar & Chemical Division, Koppers Building, Pittsburgh, has issued a booklet which gives physical and chemical properties and uses of 25 chemicals it produces from coal. Included are items commercially available and some produced on semi-commercial scale and available for laboratory use.

24—Tetrachloro Phthalic Anhydride

A new industrial chemical, Tetrachloro Phthalic Anhydride, is announced by Niagara Alkali Company, 60 East 42nd Street, New York, under the trade name of "Niathal." It is suggested for use as an intermediate or compounding material in the manufacture of dyes, pharmaceuticals, fungicides, esters, plasticizers, protective coatings, synthetic resins, synthetic rubbers, insulating materials, and lubricants.

"Niathal" is a white, odorless powder with a purity greater than 99 percent. It is free-flowing and non-hydroscopic and melts at 254-255° C. It has an appreciable vapor pressure only at elevated temperatures. The boiling point is 362° C. Experience indicates that it is non-irritating and non-toxic, but suitable precautions are recommended in making new compounds and products.

In this new chemical all four hydrogens of the phthalic anhydride molecule have been replaced by chlorine, resulting in a stable compound containing almost 50 percent chlorine. The stability and the high melting point suggest that products made from "Niathal" may be used at more elevated temperatures than those from phthalic anhydride. The high

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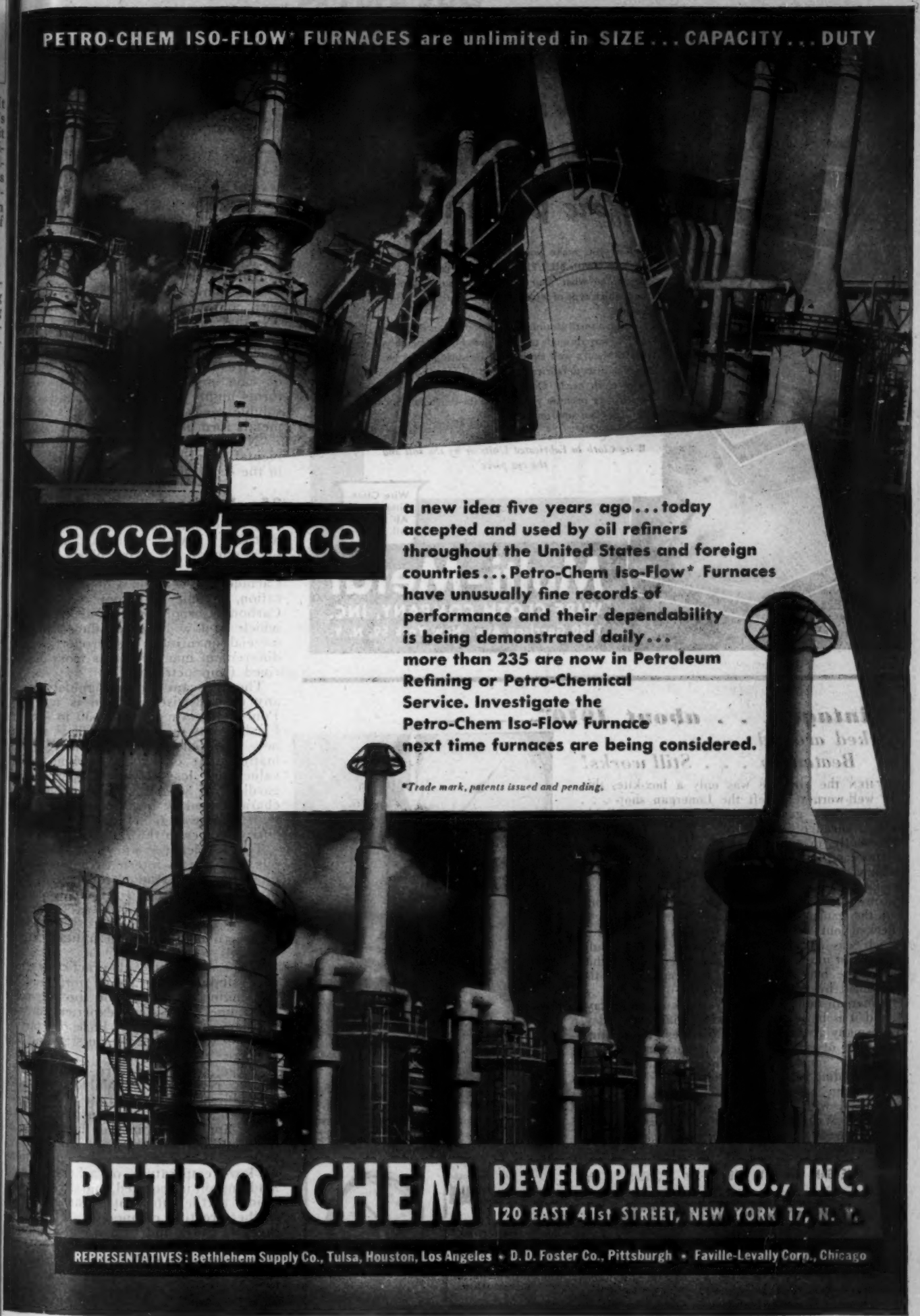

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From a small strainer to an homogenous disc, and all the way through to a complete Filter Assembly, Multi-Metal's well equipped Fabricating Shop has the facilities to fabricate any and all of your specific wire cloth needs. Our up-to-date techniques and machinery promise you bred-in-the-unit efficiency. Send for our interim catalog.

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Kicked around . . .
Beaten up . . . Still works!

WHEN the airplane was only a box-kite, this well-worn relic left the Lonergan shop . . . a shiny, new gauge with years of dependable service ahead of it.

Recently, in a shipment of old gauges sent by a customer to our Repair Department in Philadelphia for test and calibration, the sorry old wreck turned up.

Curious to see what would happen, someone put the gauge on test. It surprised everybody—checked out almost letter perfect to 140 lbs., which was as far as the battered socket would hold. Most interesting of all was the discovery that the gauge had an old slide-type movement discontinued by Lonergan in 1910!

Lonergan built good gauges back in those days—and it is building them better than ever today. With many advanced design features . . . exacting standards of manufacture . . . superior workmanship and "finish" . . . Lonergan gauges enjoy high standing all through Industry.

Lonergan gauges are made in all types and sizes . . . with nation-wide service through distributors. Write for Information Bulletin 503-A—a condensed catalog list of our most popular models.

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chlorine content also improves resistance to fire.

"Niathal" is soluble to the extent of 2-4 percent at room temperature in several organic solvents, such as acetone, benzene, and chlorobenzene. Solubilities materially increase with elevation of temperature. The acid esters, formed by dissolving tetrachloro phthalic anhydride or its acid in alcohols, are highly soluble in organic solvents.

One hundred parts of water dissolve with difficulty up to 0.33 parts of "Niathal" at 20° C., and about 1.6 parts at 90° C., forming the corresponding dibasic acid. A pH of about 2.0 characterizes this solution. With caustic soda or caustic potash solutions it readily forms highly soluble neutral, and slightly soluble acid, salts. Several common metals form nearly insoluble salts.

"Niathal" is available only in experimental quantities due to the restrictions in the supply of the raw materials.

25—Lubricant

A new internal combustion engine lubricant having unusual advantages over mineral oil, particularly for cold weather use, has been announced by Carbide and Carbon Chemicals Corporation, a unit of Union Carbide and Carbon Corporation. This lubricant, which is now being produced in commercial quantities, has properties quite different in many respects from oils derived from petroleum.

The lubricant can be manufactured to any desired viscosity and is wax free. Pour points vary from —30 to —80° F. Flash points range from 300° F. up. The new materials have densities approximating that of water. Carbon residue values are less than 0.01 percent, regardless of viscosity. The lubricant is characterized by low change of viscosity with change in temperature, having viscosity indices in the range of 140 to 160.

The lubricant contains no petroleum oils. Its use in internal-combustion engines has been studied for several years in a large number of vehicles which have covered a total of over one and one-half million road miles. Large quantities are being used in military equipment.

These new lubricants practically eliminate sludge and varnish formation in the engine. Wear of the moving parts is in line with wear experienced with ordinary mineral oils. Ease of starting in cold weather is an outstanding advantage.

These compounds are manufactured in two types, water soluble and water insoluble. The latter type is used for lubricating internal combustion engines. Other applications include lubrication of refrigerating machines and all kinds of machinery operated under conditions of low temperature or where a non-sludging oil is required, and as hydraulic fluids, textile lubricants, plasticizers, in leather treating compounds, wire drawing lubricants and heat-transfer liquids. Greases having unusual high- and low-temperature properties have been prepared from these lubricants.

Sale of these lubricants is restricted to war uses.